GRASSROOTS JOURNALS

Grassroots Journal of Natural Resources, Vol.8 No.3 (December 2025)
ISSN: 2581-6853 | CODEN: GJNRA9 | Published by The Grassroots Institute
Website: https://grassrootsjournals.org/gjnr | Main Indexing: WoS, CABELL, EBSCO

ISSN 2581-6853 | 8(3) December 2025

00611 | Research Article

Gendered Patterns Influenced by Socio-Economic Factors in Clean Cooking Technology Preferences in Rural Kenya in Lari, Kiambu County

Lilian Nyambura Gakuhi*[1], Jane Mutune[2], Bessy Kathambi[3], James Kinyua[4], Linda Obiero[5], Peter Minang[6]

[1]Department of Earth and Climate Sciences, University of Nairobi, Nairobi, Kenya.
Email: liliannyambura624@gmail.com | ORCID: https://orcid.org/0000-0002-4552-468X
[2]Department of Earth and Climate Sciences, University of Nairobi, Nairobi; Kenya' World Agroforestry, ICRAF, Nairobi, Kenya. Email: janemm@uonbi.ac.ke
ORCID: https://orcid.org/0000-0002-6243-4168
[3]Department of Earth and Climate Sciences, University of Nairobi, Nairobi, Kenya.
Email: bessyk@uonbi.ac.ke | ORCID: https://orcid.org/0000-0002-8826-2798
[4]World Agroforestry, ICRAF, Nairobi, Kenya. Email: jameskinyuagitau@gmail.com
ORCID: https://orcid.org/0000-0002-2636-908X
[5]Department of Earth and Climate Sciences, University of Nairobi, Nairobi, Kenya.
Email: linda.obiero@uonbi.ac.ke | ORCID: https://orcid.org/0000-0003-3413-5651
[6]World Agroforestry, ICRAF, Nairobi, Kenya. Email: A.Minang@cifor-icraf.org
ORCID: https://orcid.org/0009-0001-1812-0153
**Corresponding author*

How to cite this paper: Gakuhi, L.N., Mutune, J., Kathambi, B., Kinyua, J., Obiero, L. and Minang, P. (2025). Gendered Patterns Influenced by Socio-Economic Factors in Clean Cooking Technology Preferences in Rural Kenya in Lari, Kiambu County. *Grassroots Journal of Natural Resources*, 8(3): 242-291. Doi: https://doi.org/10.33002/nr2581.6853.080311

Received: 10 October 2025
Reviewed: 21 November 2025
Provisionally Accepted: 25 November 2025
Revised: 28 November 2025
Finally Accepted: 30 November 2025
Published: 31 December 2025
Copyright © 2025 by author(s)

Publisher's Note: We stay neutral with regard to jurisdictional claims in published maps, permissions taken by authors and institutional affiliations. This work is licensed under the Creative Commons Attribution International License (CC BY 4.0).
http://creativecommons.org/licenses/by/4.0/

Open Access

Executive Chief Editor
Dr. Hasrat Arjjumend
Assistant Managing Editor
Mr. Kartik Omanakuttan
Associate Editors
Dr. Usongo Patience
Dr. Nivedita Chaudhary
Pramod Ghimire

Abstract

Women, particularly in rural areas, play a central role in energy procurement for household cooking, making their perspectives critical for effective energy transitions. This study examines the socio-economic factors and preferences that shape clean cooking technology preferences in Lari, Kiambu County, with a focus on women's roles and gender equity. Findings reveal that approximately 70% of women are directly involved in fuelwood collection, highlighting their critical, yet undervalued, contribution to household energy provisioning. Despite the availability of cleaner options, 97% of households used both cleaner stoves and traditional firewood, driven by cost constraints and the need to optimize cooking efficiencies. Although health risks associated with traditional cooking methods were widely acknowledged, economic and socio-cultural constraints continue to impede full transition to cleaner energy options. Statistical analysis indicates that households engaged in agroforestry practices were associated with higher ICS utilization (Pearson's r 0.281, P=0.05). Furthermore, the age of the household head ($\beta = 3.5, P = 0.015$), the primary source of household income($\beta = 2.575, P = 0.020$) and membership in social organizations$\beta = 1.337, P = 0.049$) were identified as significant influencers of fuel preference and utilization. Women in rural settings preferred cooking stoves that are fast, easy to use, ensure family bonding during cooking, while accommodating pots suited to the household's size and fuel-efficiency, reflecting women's specific needs and practical considerations. Overall, the study emphasizes the persistent invisibility of women's labour in fuelwood collection and calls for gender-responsive clean cooking interventions that tackle economic barriers, address socio-cultural norms, and recognize the centrality of women's roles in household energy systems.

Keywords

Gender equity; Clean cooking technologies; Household energy preferences; Socio-economic factors; Rural Kenya

Introduction

Cooking technologies are integral to household welfare across the globe, playing a crucial role in nutrition, health, and environmental sustainability (Brief, 2025). Access to clean and sustainable energy is fundamental for achieving Sustainable Development Goal (SDG) 7, which emphasizes the need for universal access to affordable, reliable, and modern energy services (WHO, 2016). Significant challenges remain in delivering viable clean cooking solutions, as approximately 2.9 billion people in developing countries rely on primary energy sources such as firewood, charcoal, animal dung, and agricultural residues, typically burned in inefficient stoves (WHO, 2016). In Sub-Saharan Africa, 81% households depend on firewood for cooking (World Bank, 2011), which threatens biodiversity, causes deforestation and forest degradation, thus exacerbating socio-economic inequalities (Dagnachew *et al.*, 2020; Mutune *et al.*, 2024).

Achieving clean cooking is not merely a technological challenge; it is intertwined with social justice and gender equity (Abdelnour, Pemberton-Pigott and Deichmann, 2020; Thacker, Barger and Mattson, 2015). In Kenya, clean cooking is critical, given that approximately 75% households primarily rely on wood fuel (Ministry of Energy, 2019). This dependency escalates in rural regions, where an overwhelming 93.2% households rely on wood fuel to meet their cooking needs (Ministry of Energy, 2019). Kenya urgently needs to expedite the accessibility of clean cooking technologies, as only about 30% of rural households, and 54% of urban households currently utilize these alternatives (Ministry of Energy, 2022). Adoption and sustained use of clean cooking technologies is crucial for enhancing health outcomes, advancing gender equality and addressing climate change (Batchelor and Brown, 2020). Household Air Pollution remains a significant global health risk, contributing to an estimated 4.3 Million premature deaths annually resulting from inhalation of pollutants from use of dirty solid fuels (WHO, 2016) Alarmingly, over 60% of these deaths disproportionately affects women due to their primary roles as household cooks (WHO, 2016).

Traditional cooking practices not only exacerbate health challenges but also inflict significant drudgery on women, who are tasked with labor-intensive duties of collecting fuel and preparing meals (Karanja, 2020). Women and children, who spend long hours near the hearth, face daily exposure which can cause pneumonia in children or chronic respiratory diseases like chronic obstructive pulmonary disease - COPD (Clean Cooking Association of Kenya, 2018; Ministry of Energy, 2019). The very space meant to nourish and sustain life often becomes a silent threat to their health and well-being.

Despite severe health risks and environmental concerns associated with traditional cooking practices, the transition to clean cooking technologies faces substantial barriers that hinder their widespread adoption and consistent usage (Vigolo, Sallaku and Testa, 2018). Research has identified post-design obstacles, including affordability, social acceptability, socio-economic/demographic variations among households, unreliable supply chains, limited perceived benefits, and persistent preference for traditional cooking methods (Atieno and Odongo, 2017; Gill-Wiehl, Price and Kammen, 2021; Kong'ani, Ang'u and Muthama, 2019; Odongo, 2019; Puzzolo *et al.*, 2016). Previous research indicates that many clean cookstove designs have failed to meet women's needs and cultural preferences (Crewe, 2020; Gill-Wiehl, Price and Kammen, 2021; Thacker,

Barger, and Mattson, 2014, 2015). Gender considerations in the design of clean cooking technologies remain insufficiently addressed; incorporating user-centric perspectives into the development of clean cooking initiatives is essential (Abdelnour, Pemberton-Pigott and Deichmann, 2020). Cleaner cooking technologies enhance efficiency and promote gender equity by reducing the drudgery of household responsibilities for women and girls (Katutsi *et al.*, 2023; Njenga, Gitau and Mendum, 2021).

This study investigates how socio-economic factors and gendered preferences influence the adoption and sustained use of clean cooking technologies in rural Kenya, focusing on Lari, Kiambu County. The research identifies preferred stove characteristics, determinants of fuel choice, and gender-related challenges associated with existing technologies. The overall aim is to inform inclusive, context-sensitive clean cooking interventions that align with both household needs and gender equity priorities.

Research Methodology

Theoretical Framework

The study applied Energy Access Theory, which evaluates the availability, affordability, and sustainability of energy solutions, particularly in rural areas. This framework underscores the socio-economic, infrastructural, and policy-related challenges that shape energy utilization. From the theory, several key variables were identified: affordability, referring to the cost of energy relative to household income; availability, which includes physical presence of clean cooking technologies (CCTs), maintenance infrastructure, and distribution networks; and reliability, consistency, and quality of energy supply influencing household trust in cleaner alternatives. Additionally, socio-economic factors such as household income, education level, household size, and social group membership play a critical role in energy choices. Policy and legislation supporting government subsidies, incentives, and regulatory frameworks encourage the transition to cleaner energy solutions, while sustainability examines the long-term viability of energy sources and their environmental impact. Previous research has employed Energy Access Theory to investigate barriers and drivers of modern energy adoption, emphasizing economic constraints and policy interventions (Alegre-Bravo and Anderson, 2021; Bonan, Pareglio and Tavoni, 2017). This study expanded on these insights, integrating a gender-responsive perspective to assess the intersection of clean cooking technologies, socio-economic conditions, and sustainable energy use in rural settings. The gender lens was applied through the incorporation of gender-disaggregated variables and women-specific indicators throughout the analytical process. Key socio-economic, environmental, and behavioral variables, such as access to resources, income sources, and household energy expenditures, labor allocation, stove procurement, and adoption of agroforestry practices, were collected. In addition, the framework included women-focused indicators such as fuel collection and transport burden, health impacts from indoor air pollution, decision-making authority, and participation in community groups, which were used to interpret gendered patterns. This approach ensured that gender differences were not only acknowledged but systematically integrated into data collection, interpretation, and the study's overall assessment of equity and inclusiveness.

Doi: https://doi.org/10.33002/nr2581.6853.080311 Open Access

Description of the Study Area

The study was conducted between April and May 2024 in Kagwe Sub-location, Nyanduma ward in Lari Sub-County, Kiambu County, Kenya. Kiambu is located between latitudes 00 25◦ and 10 20◦ South of the Equator and longitudes 360 31◦ and 370 15◦East (Figure 1). Kiambu borders several counties: Murang'a to the North and North East, Machakos to the East, Nairobi and Kajiado to the South, Nakuru to the West, and Nyandarua to the North West (Kiambu, 2022). The County is predominantly rural but rapidly urbanizing due to the influence of Nairobi. Kiambu comprises 2543.4 sq.km of the central highlands, and is Kenya's fourth most densely populated county. The average farm and household size is 1.1 ha and 4.2 people, respectively (Kiambu, 2022). Altitude ranges from 1400M with mean annual temperatures between 13.4◦C to 21.9◦C and bimodal rainfall averaging 1200mm. The county comprises four major agro-ecological zones: the upper highland, lower highland, upper midland, and lower midland. Agriculture forms the backbone of local livelihoods, with households cultivating maize, beans, Irish potatoes, bananas, and vegetables. Tea and coffee represent the main cash crops. Nyanduma Ward hosts an estimated population of 23,454 residents spread across 5,945 households (KNBS, 2019).

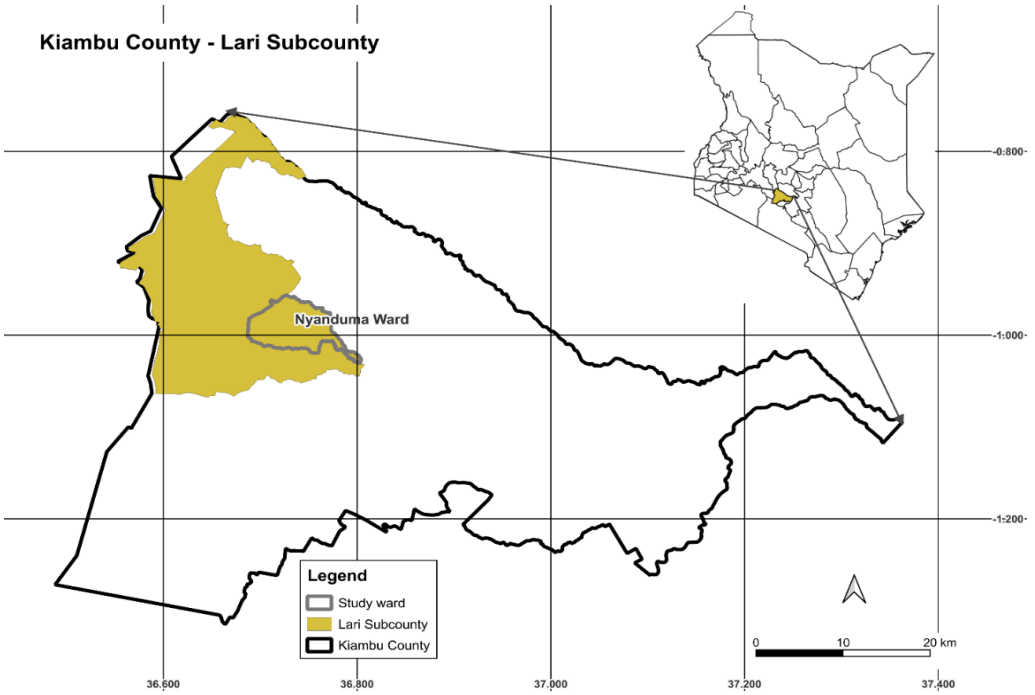

Figure 1: Outline map of the study area showing the Lari sub county

Sample Size Determination

The total number of households in Nyanduma ward is 5,945, spread across three sub-locations. To ensure a statistically valid sample, we employed the Yamane formula (Israel, 1992):

$$n = \frac{N(CV)^2}{(CV^2 + (N-1)e^2} \quad (1)$$

Where
n=Sample size
N=Population
CV=Coefficient of Variation (0.5)
e=Tolerance of desired level of confidence, 0.05 at 95% confidence interval
Using equation (1), we calculated the sample size, resulting in 100 households as primary respondents for the study.

Sampling and Selection of Households

The study focused on Nyanduma ward, which comprises three Sub-locations (Kagwe, Nyanduma, and Gatamaiyu). A preliminary reconnaissance survey established that all three sub-locations used comparable cooking technologies; however, Kagwe Sub-location exhibited a greater diversity of clean cooking technologies, making it the most suitable site for in-depth investigation.

Households were the primary sampling units. From a sampling frame of 171 registered households across eight villages in Kagwe, a total of 100 households were selected using systematic random sampling procedures. In addition, all households using biogas technology were deliberately included through purposive sampling, and a census of all 35 biogas households was conducted to ensure adequate representation of this subgroup.

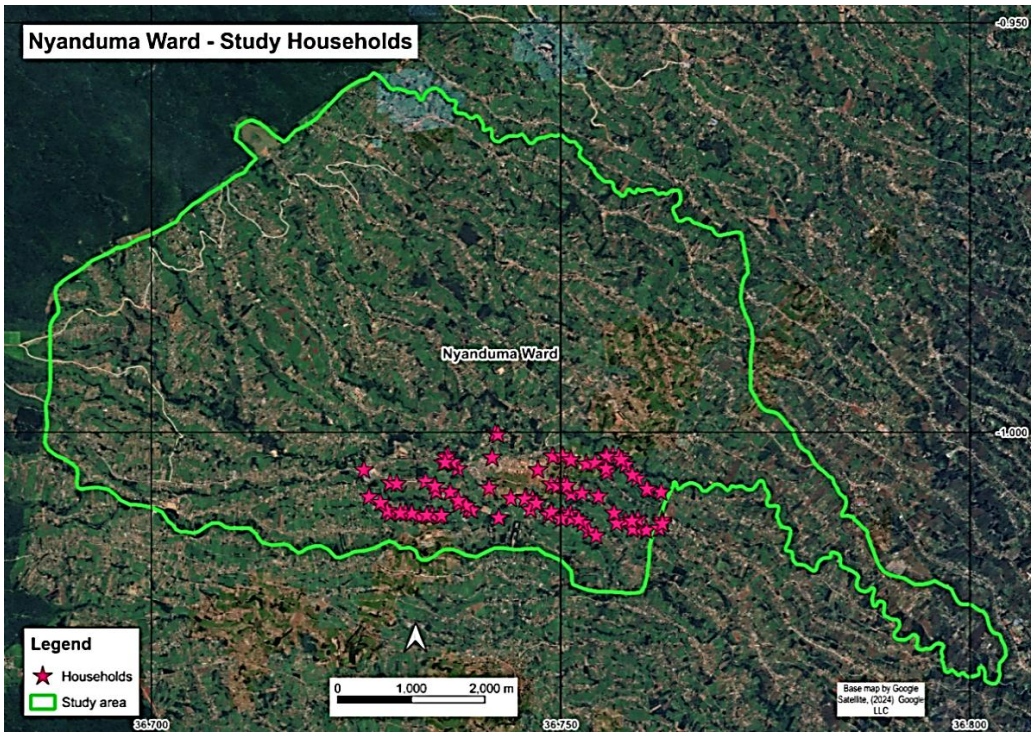

Figure 2: Map of Nyanduma ward showing households sampled and surveyed in Kagwe Sub-location

Research Design

The study employed a cross-sectional research design and utilized a descriptive survey method that used quantitative and qualitative techniques. Initially, a reconnaissance survey was conducted to assess the feasibility of the study site and research objectives and to initially document clean cooking technologies utilized by households. A household survey semi-structured questionnaire was developed, which consisted of 94 closed and open-ended questions. The questionnaire was pretested for clarity and relevance before the study's full-scale implementation. Four enumerators from the local area were selected and trained in using the Open Data Kit (ODK) software for effective data collection. The research design also incorporated gender-disaggregated analysis to capture women's experiences and preferences in relation to clean cooking transitions. The study was limited as it focused exclusively on rural households in Kiambu County, a central region of Kenya.

Data Collection

Quantitative data were gathered through oral administration of questionnaires. Questionnaire surveys using ODK were conducted on the 100 designated households to gather data on household demographics, cooking energy, and stove usage, and socio-economic and institutional factors influencing cleaner cooking technologies. All 100 questionnaires were administered successfully, representing a 100% response rate, which was very encouraging. To complement and contextualize the survey data, two Focus Group Discussions (FGDs) with eight purposively selected participants each, comprising both clean cooking technology users and non-users, were conducted to fill information gaps identified during analysis of household survey data. The FGDs were guided by a checklist of open-ended questions. Qualitative data were gathered from published secondary literature sources and key informant interviews (KIIs) with institutions dealing with clean cooking technologies.

Data Management and Analysis

The duly filled questionnaires' data were checked for completeness and cleaned using SPSS. Data analysis used tables, percentages, and Pearson's chi-square test, along with correlation analysis, to explore significant correlations between ownership of clean cooking technologies and various socio-economic characteristics of households. A binomial regression model was used to determine the influence of socio-economic factors on households' fuel choice. The significance level was set at $P<0.05$. Qualitative data from FGDs, KIIs, and secondary sources were analyzed through comprehensive and in-depth textual analysis, enabling triangulation with quantitative findings and deeper interpretation of household preferences and barriers to clean cooking technology adoption.

Ethical Considerations

To ensure the integrity of the study, the researchers prioritized ethical conduct throughout the research process. Participants were assured of the confidentiality of the information they provided and were given a clear and comprehensive explanation of the

study's purpose. Their identities were kept anonymous in all presentations of the research findings. Informed consent was obtained from all participants before data collection commenced. Furthermore, proper attribution of all sources was diligently maintained to uphold academic integrity.

Results and Discussions

Socio-Economic Characteristics of Households in Lari Sub-County

Socio-demographic analysis showed that female respondents accounted for a higher proportion (67%), indicating a greater involvement in household cooking compared to men (33%). The mean age of households' respondents was 56 years (range 20-81), and the mean household size was four people (range 1-8), mean number of years in school was 10 years (range 0-16). Stacking, which is the use of multiple cooking fuels and multiple stoves, was common with households stacking an average of three fuels (range 1-6) and three stoves (range 1-4). The households purchasing cooking fuel spent on average KSh 662 (USD 5.1) weekly. The households using improved cookstoves indicated that the average cost of one Improved cookstove (ICS) was KSh 1025 (USD 7.9) (Table 1).

Table 1: Summary of respondents' household characteristics in Lari

Socio-economic characteristics			*N*	*Mean*	*Std. Error of mean*	*Std. deviation*	*Range*
Gender	Male	33	100				
	Female	67					
Age (years)			100	56	0.06	0.6	20-81
Household size			100	4	0.17	1.77	1 – 8
Years in school of respondents			100	10	0.39	3.97	0-16
Weekly expenditure on cooking fuel (KSh)			86	662	90.7	842	25-1750
Cost of ICS (KSh)			63	1025	189.9	1507.3	250 - 10,000
Average number of cooking fuels used in a household			100	3	0.093	0.93	1-6
Average number of cooking devices used in a household			100	3	0.83	8.30	1-4

Household Size and Clean Cooking Technology Use

Household size was considered as the number of people who live and are fed within the surveyed households daily. The size of household ranged between 1-2 persons at 27%, with most households at 53% having between 3-5 individuals, while a few households, 20% had between 6-8 individuals. The average household size was four people per household. The findings align with the Kiambu CIDP report of 2022, which reported that the average household size in Kiambu County is 4.2 persons per household (Kiambu, 2022). Results showed that households between 3-5 individuals adopted the use of improved cookstoves for their household cooking at 52% followed by those of 1-2

individuals at 27% and 6-8 individuals at 20%. Pearson correlation between ICS ownership and household size was 0.055 at a P-value of 0.586, indicating a positive but statistically insignificant relationship. The FGDs revealed that larger households tend to rely on firewood for cooking, as the adjustable three-stone fireplace offers greater flexibility. This highlights the need to develop larger, cleaner cooking stoves and technologies that cater to the preferences of these households. Similarly, Nyankone (2018) observed higher ICS adoption among smaller households compared to larger households.

Previous studies have shown that large household size hinders Clean Cooking Technologies (CCTs) utilization as clean cookstoves are often small for the cooking needs of large families (Brooks *et al.*, 2016; Gitau *et al.*, 2019; Kong'ani, Ang'u and Muthama, 2019; Odongo, 2019). Gitau *et al*. (2019) found that large households in Kwale County prefer traditional cookstoves due to pot size limitations (Gitau *et al*., 2019). Similarly, Mohapatra and Simon (2017) noted that larger households are more traditional and less likely to adopt modern cooking technologies.

Age of the Respondents in Lari Sub-County

The respondents were aged between 23 to 81 years, with the highest number 75% in the range of 45-81 years, 18% aged between 30-45 years, and 7% aged between 20-30 years. Findings indicate that those aged 45 and above invested more in using CCTs, often utilizing three-stone fires for space heating or larger gatherings. Key informant interviews revealed that older household heads showed stronger interest in biogas systems compared to younger individuals, who perceived the technology as less desirable. Younger adopters often relied on parental encouragement rather than personal initiative. Previous research suggests that age influences adoption, with older, often female household heads, more likely to use clean stoves (Brooks *et al.*, 2016) However, in this study, Pearson's correlation showed a weak, negative, and statistically insignificant relationship between age and ICS ownership in Lari (r=-0.054, *P*= 0.595). This suggests that while age may influence perceptions and motivations, adoption decisions are likely influenced more strongly by interacting factors such as household needs, income levels, educational attainment, and seasonal heating requirements, issues also highlighted in the FGDs.

Education Level of the Respondents in Lari Sub-County

Most respondents, 94% had some form of formal education, with 73% having achieved secondary education or higher (Figure 3). The results indicate that individuals with higher education levels tend to utilize clean cooking technologies more (Table 2). Education likely enhances awareness of health risks from traditional cooking fuels, increases willingness to adopt modern technologies, and influences decision-making capacity within households.

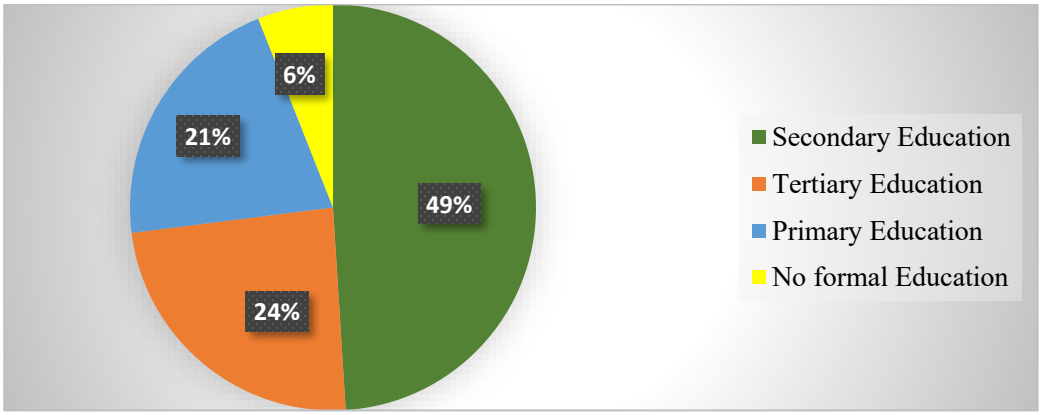

Figure 3: Literacy status of respondents in Lari

Table 2: Comparison between the level of education of respondents and ICS ownership in Lari Sub-County

Highest level of education	*Percentage LPG ownership (n=65)*	*Percentage ICS ownership (n=97)*
No formal education	1	6
Primary education	12	18
Secondary education	32	49
Tertiary education	20	24

From household surveys, Pearson's correlation analysis revealed a significant positive relationship between education level and LPG ownership (r= 0.349, P= 0.000), suggesting higher education correlates with increased LPG use among households. Conversely, the relationship between education and ownership of improved cookstoves (ICS) was weak and statistically insignificant (r = 0.081, p = 0.425), suggesting that education alone does not predict ICS adoption within the study area.

These results align with Wilson *et al.* (2016), who posited that education enhances awareness of the negative health and environmental effects of biomass fuels and encourages the shift toward modern cooking technologies. Numerous studies equally report that respondents with higher levels of education are more likely to adopt improved cookstoves, regardless of gender (Brooks *et al.*, 2016; Mohapatra and Simon, 2017; Odongo, 2019). Exceptionally, Gitau *et al*. (2019) reported no significant effect of education on the use of Top-lit Updraft TLUD gasifier stoves in Kwale County. Similarly, Troncoso *et al.* (2007) reported that education was not a significant predictor of early ICS adoption in rural Mexico; instead, they found that open-minded women are more likely to utilize ICS, regardless of the length of their formal education.

Marital Status, Household Headship, and Adoption of Clean Cooking Technologies in Lari Sub-County

Most respondents were married, with 80% households being male-headed while 20% female-headed (Figure 4), reflecting a social structure in rural Kenya where men dominate decision-making roles. Consequently, women are ultimately positioned second in household decision-making regarding the procurement of household cooking

Doi: https://doi.org/10.33002/nr2581.6853.080311 Open Access

technologies. Results of the chi-square test revealed no significant relationship between marital status and clean cooking ownership ($x^2(3) = 0.253, P = 0.969$) nor between the gender of the household head and technology ownership ($x^2(1) = 0.253, P = 0.615$). These results suggest that although gender roles influence how energy decisions are negotiated within the household, they do not directly determine whether a household adopts cleaner cookstoves. This aligns with findings by Odongo (2019), who noted that while traditional norms assign cooking responsibilities to women and financial control to men, these roles do not necessarily translate into predictable patterns of clean cooking technology ownership. Instead, adoption decisions may be shaped more strongly by factors such as income, availability, cost of technology, and perceived usefulness than by marital status or household headship alone.

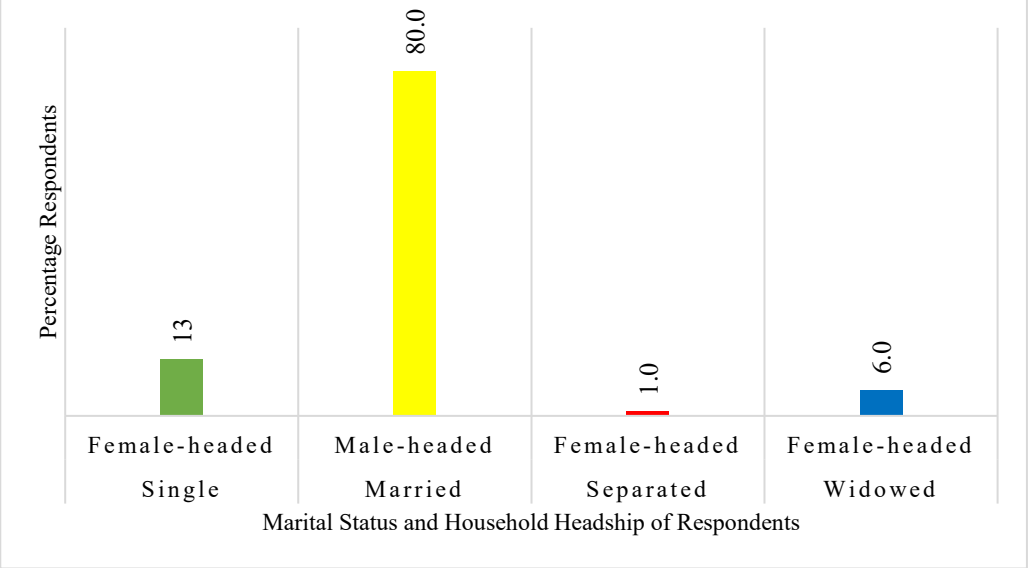

Figure 4: Marital status and household headship of respondents (n=100)

Major Source of Income for Households

The research found that a significant portion of the community relies on crop farming (53%) and animal farming (32%) for their livelihood. Pearson's correlation between the major source of income and ICS ownership showed a weak, negative correlation (r=-0.114, P=0.259), indicating no statistically significant relationship. Contrary to the findings, several past studies have found that household income has a major influence on the adoption of CCTs, with high-income households utilizing CCTs more compared to low-income households (Akomolafe and Ogunleye, 2017; Atieno and Odongo, 2017; Nyankone, 2018).

Household Membership to Social Organizations

Most households (89%) belonged to at least one social organization, with an average membership of two groups per individual. Both household surveys and FGDs revealed the importance of belonging to social organizations in facilitating information exchange, community mobilization, and training on clean cooking technologies (Figure 5). Some

FGD participants highlighted that they acquired their LPGs through social groups, while others reported having been trained on how to make fireless cookers and briquettes through social groups. FGDs indicated that social groups were empowerment platforms through which sustainable community practices like agroforestry are taught. Pearson's correlation between group membership and ICS ownership was positive but very weak ($r = 0.035$, $p = 0.727$), indicating no statistically significant relationship ($p < 0.05$). Although statistically insignificant, qualitative findings demonstrate that social networks may nonetheless play an influential role in shaping awareness and attitudes toward CCTs.

Leveraging social organizations can significantly improve the utilization of CCTs, as studies in rural India (Kumar and Igdalsky, 2019) and a systematic review by (Vigolo, Sallaku and Testa, 2018) highlights the crucial role of social networks in effectively disseminating innovations and positively influencing consumer decisions. FGDs indicated that NGOs such as GROOTS Kenya & KENVO are primarily responsible for training and raising awareness on CCTs, with no reported government initiatives promoting CCTs in the community.

Figure 5: Influence of household membership on social organization on ICS utilization (*n=100*)

Cost and Affordability of Clean Cooking Technologies by Households in Lari Sub-County

The average price at which households bought their ICS was KSh 1050 (USD 10), with 75% of respondents perceiving this cost as fair. Approximately 25% of respondents reported that a good ICS was expensive to afford, and competing household demands often led others to revert to traditional fires to save on fuel costs. Most respondents and FGD participants decried that costs associated with CCTs extend beyond the initial purchase price, noting that biogas systems require diligent maintenance and careful adherence to instructions to prevent malfunction. They pointed out that ongoing maintenance and repair expenses are significant factors, a finding supported by previous

studies in rural Uganda, emphasizing the importance of considering these additional expenses to enhance the adoption and sustained use of CCTs (Diaz Ruiz and Makkar, 2021; Katutsi *et al.*, 2023).

Some biogas users expressed that the overall cost of biogas extends beyond initial installation expenses, as it requires regular maintenance to ensure optimal performance. Although they are willing to seek technical assistance, many reported challenges in accessing the support needed for maintenance. Additionally, while most respondents viewed LPG as an efficient, clean cooking technology, they cited high refill and delivery costs as major financial burdens. Furthermore, access to and price of LPG were reported to be a concern in most rural households, and due to its higher cost, respondents used LPG with biomass to save on expenses. This finding aligns with Puzzolo *et.al* (2016), who found that the cost of LPG refills hindered full utilization by households. For the LPG stove, the high initial cost of purchasing cylinders was reported as a barrier by various studies (Rehfuess *et al.*, 2014; Vigolo, Sallaku and Testa, 2018).

Cooking Energy Typologies and Means of Procurement

From the household surveys and FGDs, the most common types of cooking fuels used by households in the study area are unclean traditional biomass-based solid fuels, notably firewood and charcoal, at 91% and 72% respectively (Figure 6). Participant observation and informal interviews revealed that a high preference for firewood is due to local availability, ease of access, and low costs involved in collecting and utilization of fuelwood.

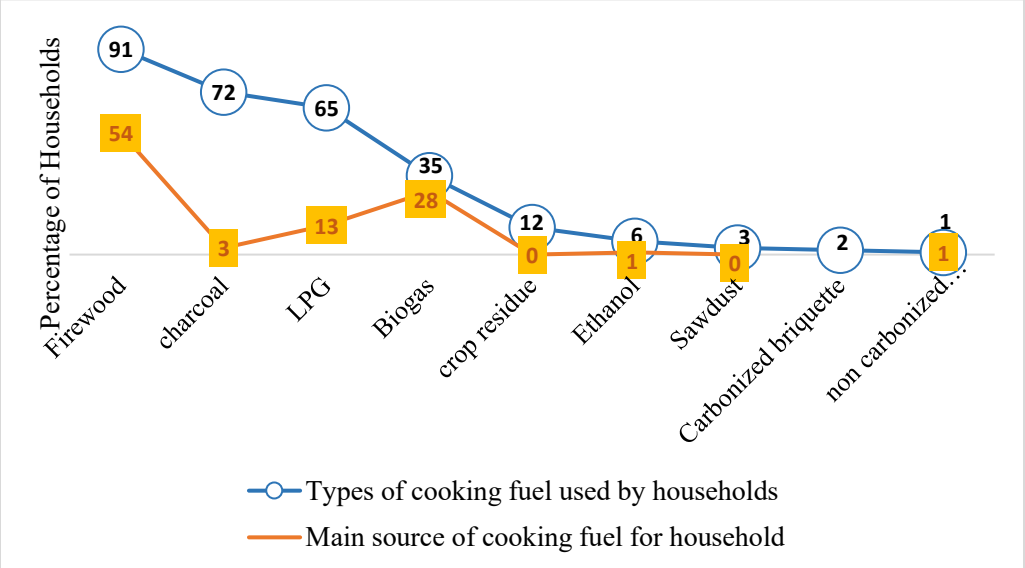

Figure 6: Types of cooking energy sources used by households in the study (*n=100*)

Past research indicates that when biomass is freely or cheaply available, households lack economic motivation to invest in improved cooking solutions, especially if they are unaware of the health hazards caused by smoke from traditional stoves (Wang, 2018). Some women opined that firewood produces tastier foods and fosters family bonding, as

Doi: https://doi.org/10.33002/nr2581.6853.080311 Open Access

the fireplace serves as a central gathering point during cooking, a sentiment echoed in various studies and anecdotal evidence. For instance, Odongo's (2019) study in Western Kenya revealed that three-stone open fire (TSOF) is preferred for preparing *ugali*, a cultural food in the region, as it maintains the preferred taste which cannot be achieved using ICS, forcing households to continue using conventional stoves. Kong'ani, Ang'u and Muthama (2019) made a similar finding that adherence to the distinct flavor of cultural foods cooked on traditional stoves serves as a deterring factor to the adoption of clean cookstoves. The authors further found that socio-cultural factors impede the implementation of clean cookstoves, highlighting that the preference for cooking staple foods like *githeri* (mix of beans and maize) on a traditional stove and attachment to the taste of food cooked on a traditional stove affect the adoption of cleaner cookstoves (Kong'ani, Ang'u and Muthama, 2019). According to the Kiambu County Integrated Development Plan (CIDP) 2018-2022, 47.3% of households use firewood for their domestic cooking needs; hence, the use of firewood in the study area is above the Kiambu County average (Kiambu, 2022).

Households in the study area obtained their main types of cooking energy from various sources (Figure 7). The results indicated that women predominantly collect firewood from their own farms, with only a small proportion purchasing it. FGDs revealed that some households collect firewood from nearby forests either for commercial or domestic use, by purchasing permits costing KSh 1000 (USD 7.74) and KSh 300 (USD 2.32) monthly, respectively. The commercial permit allows multiple daily trips, while the domestic permit limits women to one load per day. Both permits limit the types of tools allowed; machetes are permitted, while axes and saws are prohibited. Women and girls travel about 20km round trip, facing risks of wild-animal attacks, sexual violence, and occasionally extra-legal charges or harassment by forest officers.

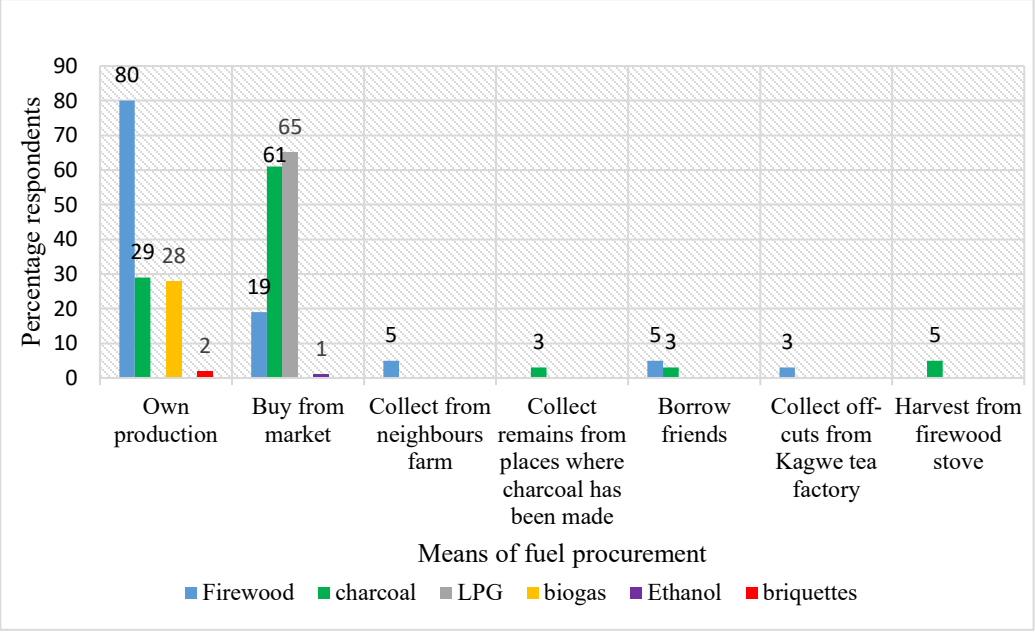

Figure 7: Means used by households in fuel procurement

Agroforestry Practices and Utilization of Improved Biomass Stoves

A correlation analysis showed that agroforestry, i.e., active integration and growing of trees in farms, has a favorable impact on utilization of improved biomass stoves with a Pearson's (r) 0.281 at *P-value* 0.05, hence a statistically significant positive relationship. This confirmed the findings of Karanja (2020), who found on-farm tree growing as a significant factor influencing the adoption of improved cookstoves. Kenya's Bioenergy Strategy (2020-2027) promotes the utilization of agricultural residues and agroforestry systems, supporting clean cooking and rural energy access while creating income streams for farmers (Bioenergy strategy, 2020). Integrating on-farm tree cultivation with the use of CCTs is a climate-smart practice capable of significantly reducing carbon emissions, enhancing carbon sequestration, improving the livelihoods of smallholder farmers, and fostering ecosystem restoration (Mutune *et al.*, 2024; Nayak, Sahoo and Singh, 2018). Previous studies have demonstrated that growing trees on-farm gives women opportunities to improve their livelihoods, thus alleviating daily drudgery associated with fuelwood collection (Foncha and Eforkwe, 2024; Nayak, Sahoo and Singh, 2018; Njenga, 2017; Njenga, Gitau and Mendum, 2021). Some FGD participants noted that agroforestry does not sufficiently meet their high firewood demands, as their limited land holdings leave only small areas available for such practices.

Households collecting firewood from their farms mainly obtained it through pruning on-farm trees (Figure 8). Pruning is a sustainable practice that contributes to the preservation of on-farm tree resources while also reducing deforestation pressure and negative environmental impacts (Ajijur *et al.*, 2017). Pruning on-farm trees provides households with an affordable and convenient source of firewood (Njenga, 2017).

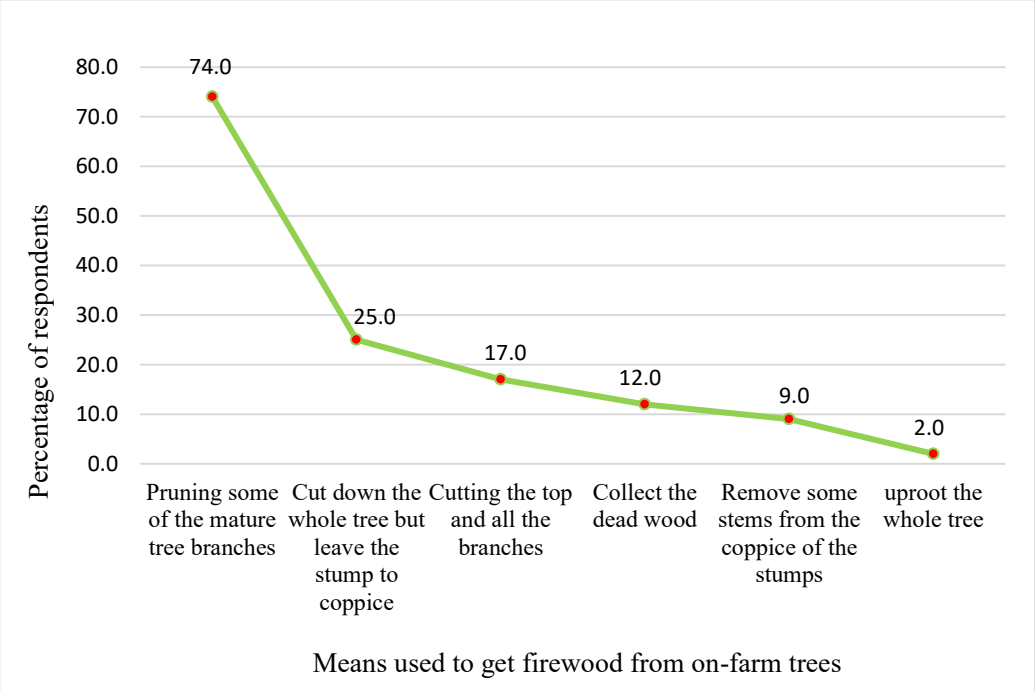

Figure 8: Firewood sourcing practices from on-farm trees

Household Decision-making on Cooking Technology

Survey data showed that t 84% households purchased some form of cooking fuel, with the male spouses responsible for financing these purchases in half of the households. FGDs indicated that women typically buy more affordable energy-saving jikos, while men hold authority and make final decisions on purchasing more costly CCTs. This observation may indicate that male spouses may have greater influence over financial decisions within households, indicating disparity in economic control. Multiple studies emphasize that women are more likely than men to utilize clean cookstoves (Atieno and Odongo, 2017; Karanja, 2020; Rehfuess *et al.*, 2014). However, since men often control household finances, women frequently struggle to assert their preferences or allocate resources towards cleaner cooking options (Bonan, Pareglio and Tavoni, 2017). The dynamics of decision-making can also differ markedly, depending on household headship; for instance, research conducted in Kenya by Odongo (2019) demonstrated that male-headed households were more likely to use clean cookstoves compared to their female-headed counterparts. Similarly, Karanja (2020) found that female-headed households in Kiambu County exhibited a lower likelihood of adopting improved cookstoves as their primary cooking solution.

Contrastingly, a study in India reported a positive correlation between female-headed households and the use of clean cookstoves (Brooks *et al.*, 2016). In Ethiopia, Mamuye *et al*.(2018) discovered that married women in male-headed households were less likely to adopt improved cookstoves compared to women in female-headed households. Consequently, gender in household headship may emerge as a significant barrier to the utilization of clean cookstoves within households, underscoring the need for policies that empower women financially and promote equitable decision-making that favors sustainable cooking solutions.

Typologies of Biomass Cookstoves used in Households and Preferences Influencing their Utilization

The majority of households in the study area (88%) owned an improved biomass stove. The household survey identified 11 categories of biomass stoves that were being utilized by households (Figure 9). The three-stone open fire (TSOF) was the most popular cooking solution among 49% households, followed closely by the Kenya Ceramic Jiko (KCJ)**.** The utilization of TSOF was lower in the study area compared to the national statistics, where approximately 59% of households in Kenya use the three-stone fire as their primary cooking solution (Ministry of Energy, 2019)**.** Most households practiced stove stacking, with a preference for TSOF for cooking cultural foods like *githeri*, hard cereals, and *ugali,* with most households noting that they preferred the taste of ugali cooked on TSOF.

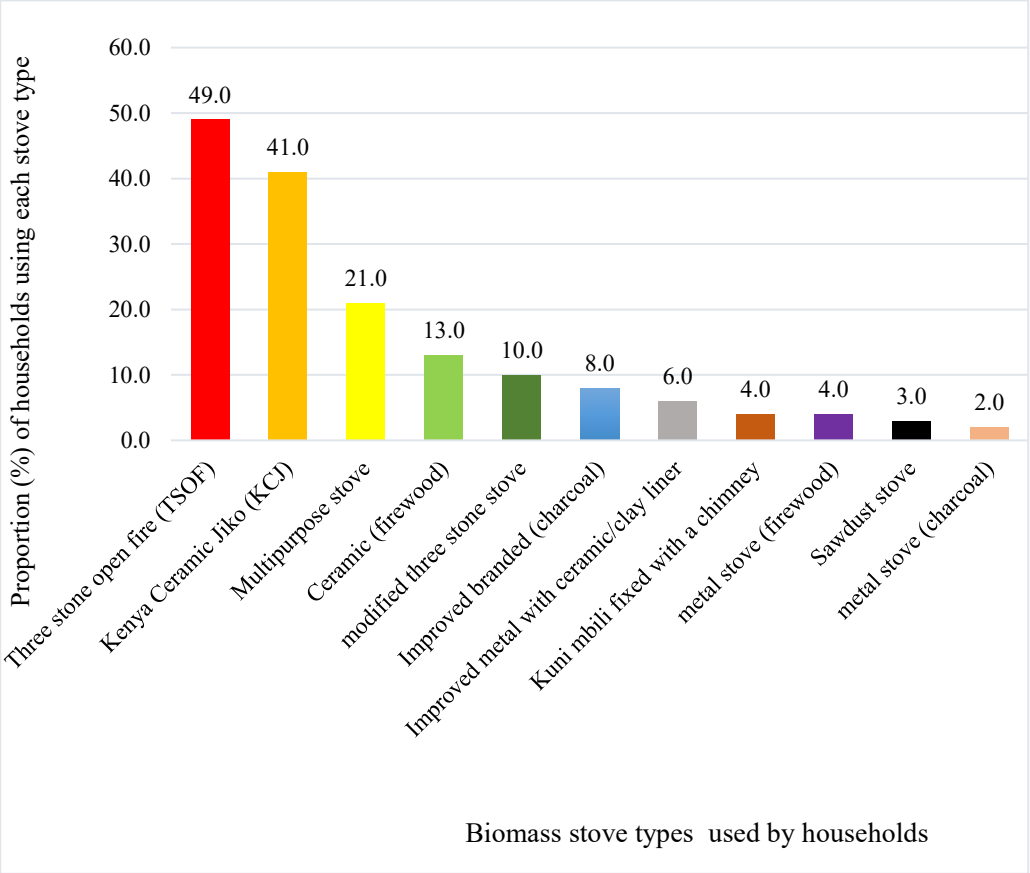

Figure 9: Types of biomass stoves utilized by households in Lari Sub-County (*n=100*)

Many women preferred TSOF due to easy access to firewood from their farms, its adjustable setup suitable for various pot sizes, its ability to provide warmth on chilly nights, and its high cooking efficiency when using properly dried firewood. However, some drawbacks to this cooking method included excessive smoke production, heat loss into the surrounding environment, and high firewood consumption.

Gendered Responsibilities in Fuel Procurement

Crucially, the dynamics of fuel collection within households showed gender disparities, with 70% of fuel procurement tasks being undertaken by women and girls (Table 3). The physical and social implications of this responsibility impact women's daily health and overall well-being (Iiyama *et al.*, 2014; Puzzolo *et al.*, 2016).

The results confirmed findings of Karanja (2020) that firewood procurement in rural households is a distinctly gendered responsibility, with women and girls disproportionately responsible for gathering it. Women are the primary firewood collectors because of ingrained gender roles linking women to household tasks like cooking, and therefore bear the responsibility of sourcing fuel for these tasks. This perpetuates unequal distribution of labour, also exposing women to health issues of respiratory diseases and physical injuries (James *et al.*, 2020; Njenga, Gitau and

Mendum, 2021). The disproportionate burden of firewood collection limits women's economic opportunities for income generation and overall empowerment. FGDs revealed that some men fetch firewood from the forest mainly for commercial purposes, with women collecting firewood on their behalf and handing it over at the forest edge.

Table 3: Gender involvement in firewood procurement in households, in Lari

Persons in charge of firewood collection (n=91)	*No. of people involved (Percentage)*
Wife	48%
Male employee	15%
Daughters>18 years	10%
Sons> 18 years	9%
Female children<18 years	8%
Husband	4%
Female employee	2%
Male grandchildren	2%
Female grandchildren	1%
Female relative	1%

Means of Transporting Firewood to Households

The study revealed that in 82% of households, individuals, predominantly women and girls, collect and transport firewood by carrying it on their backs (Figure 10). Carrying heavy loads of firewood can lead to physical strain and health issues, such as back pain, muscle strains, and injuries, presenting potential health risks, especially if they are carrying the heavy loads over long distances (Rehfuess and WHO, 2006).

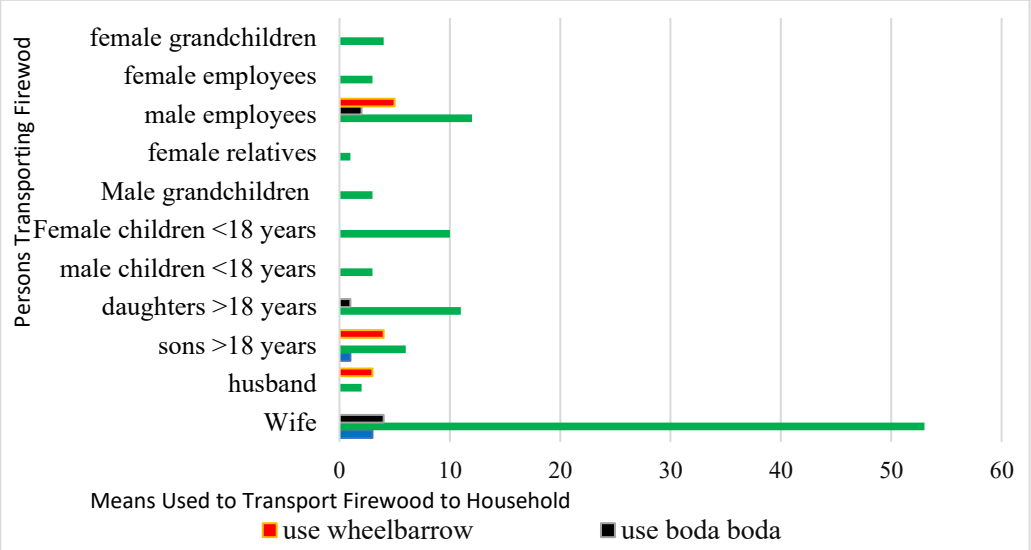

Figure 10: Means used to transport firewood to the households

Doi: https://doi.org/10.33002/nr2581.6853.080311 Open Access

Household Cooking Practices and Indoor Cooking

The majority of women in the study area (81%) utilize biomass stoves indoors primarily due to cultural norms surrounding indoor food preparation and perceived sense of security associated with indoor cooking (Figure 11). The high usage of biomass stoves indoors suggests a high likelihood of significant exposure to indoor air pollutants resulting from combustion activities, which could have potential health implications. In poorly ventilated dwellings, the concentration of fine particles in indoor smoke can reach levels 100 times higher than what is deemed acceptable (WHO, 2022). Women and children are particularly at risk, as they tend to spend more time near the domestic hearth (WHO, 2022).

Evidence from past studies shows that using cleaner cookstoves in households reduces indoor air pollution significantly (Gitau *et al.*, n.d.; Njenga *et al.*, 2016; Singh *et al.*, 2012). Njenga *et al*. (2016) found that in rural Kenya, using a gasifier instead of TSOF led to a reduction in CO and PM2.5 emissions by 45% and 90%, respectively. Likewise, Singh *et al*. (2012) observed that in Khairatpur village in rural India, adoption of ICS reduced emissions of various pollutants by 30%.

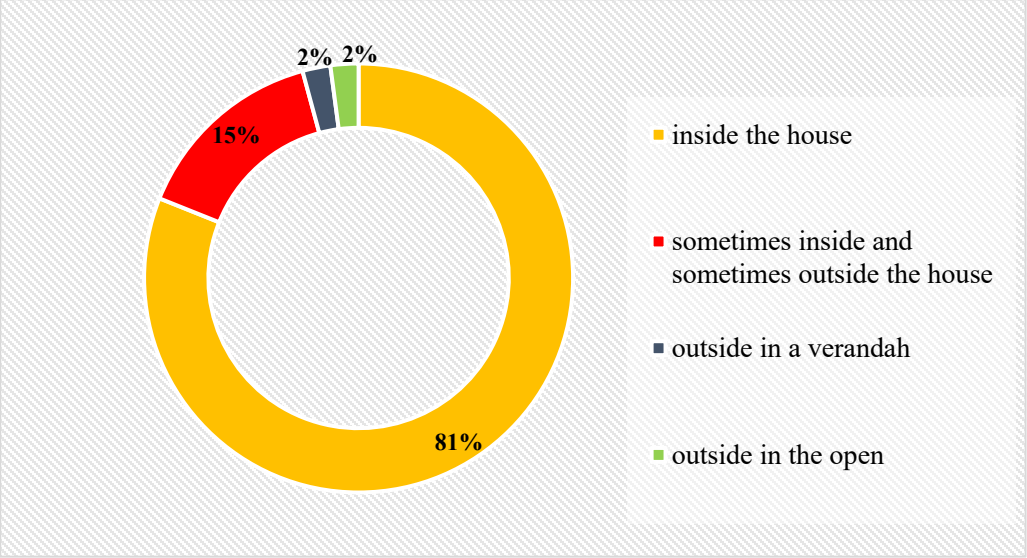

Figure 11: Place where households use their biomass stoves (n=88)

Health Implications of Indoor Cooking

Five percent of households indicated that their family member had suffered from a respiratory problem (2% asthma, 2% irritating coughs, and 1% breathing difficulties), which they associated with indoor air pollution. Nearly all FGD participants complained of eye irritation and breathing difficulties while cooking with firewood, and some reported vision problems resulting from prolonged exposure to smoke during cooking. Additionally, FGDs revealed that women often use harmful materials such as plastics, carrier bags, old shoes, and mattresses to ignite firewood, increasing the health risks. All household members who had suffered from respiratory illnesses were women. These results confirm findings of Gill-Wiehl, Price and Kammen (2021), that women bear the

biggest burden of respiratory illnesses from household air pollution (HAP), which is linked to their being primary household cooks (Gill-Wiehl, Price and Kammen, 2021; WHO, 2022). The findings underscore the need for targeted interventions and policy initiatives to improve CCT access in rural areas.

Socio-Economic Factors Influencing Household Cooking Fuel Choices

According to binary logistic regression analysis, four independent variables (predictors) were statistically significant in influencing the choice of main fuel in a household, including age of household head, major source of household income, household size, and membership to a social organization (Table 4).

Table 4: Influence of socio-economic factors on households' choice of main cooking fuel

Variable	*β*	*S.E.*	*Wald*	*D.f.*	*Sig.*	*Exp(β)*
Age	1.253	0.728	2.964	1	0.015*	3.5
Major source of income	2.575	1.109	5.389	1	0.020*	13.14
Household size	-0.929	1.682	0.305	1	0.063*	0.39
Marital status	-0.702	1.309	0.287	1	0.592	0.5
Member of a social organization	1.337	1.035	1.666	1	0.049*	3.8
Gender of household head	0.85	0.9	0.893	1	0.344	2.34
Constant	-24.172	40192.67	0	1	1	0

Note: * Significance
Chi-square: 38.541 at df 8 and P 0.030
Number of Observation = 100
Pseudo R2: Cox and Snell R square = 0.320 Nagelkerke R square = 0.429 Dependent variable coding (1= cleaner fuel, 0= Polluting fuel)
Source: Binary Logistic Regression

The analysis revealed a significant association between the age of the household head and the choice of main cooking fuel utilized by households ($P = 0.015$). The finding suggests that as the age of the household head increases, there is a high likelihood of the adoption and utilization of cleaner cooking energy options by a factor of 3.5. This trend may be due to increased health and environmental awareness and better financial stability, facilitating the transition to cleaner alternatives. Conversely, some studies suggest that older household heads prefer traditional cooking fuels, a behavior influenced by perceptions, beliefs, and culture (Akintan, Jewitt and Clifford, 2018; Ahmed, 2024).

Results equally indicated the principal source of household income is a significant predictor of household cooking fuel choice (P=0.020). The results revealed that rural-farming households are more likely to utilize clean cooking energy options by a factor of 2.575, possibly due to their focus on sustainability and better access to resources that support clean energy choices, such as agricultural waste or biogas derived from livestock. Previous findings reveal that household income highly influences clean cookstoves utilization, with wealthier households often using sustainable clean cooking

systems than poorer households (Atieno and Odongo, 2017; Jan *et al.*, 2017). The analysis revealed that household membership to a social organization is significantly associated with the households' choice of primary cooking fuel in households ($B = 1.337$, $P = 0.049$). This implies that membership in social organizations positively influences rural households' fuel choices by a factor of 1.337. This aligns with Ahmed (2024), who found that engagement in community social networks increases the likelihood of adopting transitional cooking fuels.

Factors Influencing the Utilization of Improved Biomass Stoves by Households

Chi-square analysis indicated that marital status significantly influenced the use of improved biomass stoves by households ($x^2 = 8.872(3), P = 0.031$). Similarly, a recent study found that being married reduced the likelihood of adopting cleaner cooking solutions by 1.8% and increased the likelihood of adopting traditional cooking options by 3.2% (Ahmed, 2024). Conversely, Mamuye *et al*. (2018) found that married women were less likely to adopt improved cookstoves compared to women from female-headed households. Additionally, correlation analysis showed that agroforestry favored the utilization of improved biomass stoves with a Pearson's (r) 0.281 at *P_value*0.05.

Stove-related factors (cost, size, durability, accessibility) were positively correlated with improved biomass stove ownership but were not statistically significant. FGDs identified key desired features in an ideal ICS: durability, adjustable size, reparability, low firewood use, affordability, fast cooking, and the ability to radiate heat safely for the elderly during cold seasons. This finding confirmed the results of Rehfuess *et al*. (2014) and Odongo (2017), who found that stove characteristics, including size, cost, durability, and design, influence the adoption and use of clean cookstoves.

Challenges Experienced with Current Cleaner Cooking Technologies Utilized by Respondents' Households

The utilization of cleaner cooking technologies, while crucial for mitigating indoor air pollution (IAP), faces significant hurdles for many households. Current improved biomass cookstoves often exhibit limitations that hinder their widespread and effective use (Figure 12). Improved biomass stoves often produce excessive smoke, leading to high IAP and associated respiratory health risks, especially for women and children, as noted by James *et al*. (2020). IAP perpetuates health disparities within vulnerable communities (James *et al.*, 2020). Similarly, high fuel consumption poses a significant economic burden, potentially limiting household access to essential resources. Though there are financial constraints associated with the transition to cleaner technologies, previous studies reveal that the use of improved cookstoves can significantly reduce fuelwood consumption (Kooser and Toman, 2018) Another challenge includes high heat loss to the surroundings, which resonates with Andandoh and Yuntenwi (2008), who noted that open fires have low efficiencies of between 5-10% heat transferred from firewood, while the rest is lost to the surroundings. Challenges concerning fuel preparation add further complexity, mirroring past studies that found that challenges with fuel preparation, lighting, and reloading fuel can hinder the adoption of improved cookstoves (Gitau *et al*., n.d.; Gitau *et al.*, 2019). Finally, concerns regarding stove

portability, cooking capacity, and durability underscore the need for more user-friendly and robust designs.

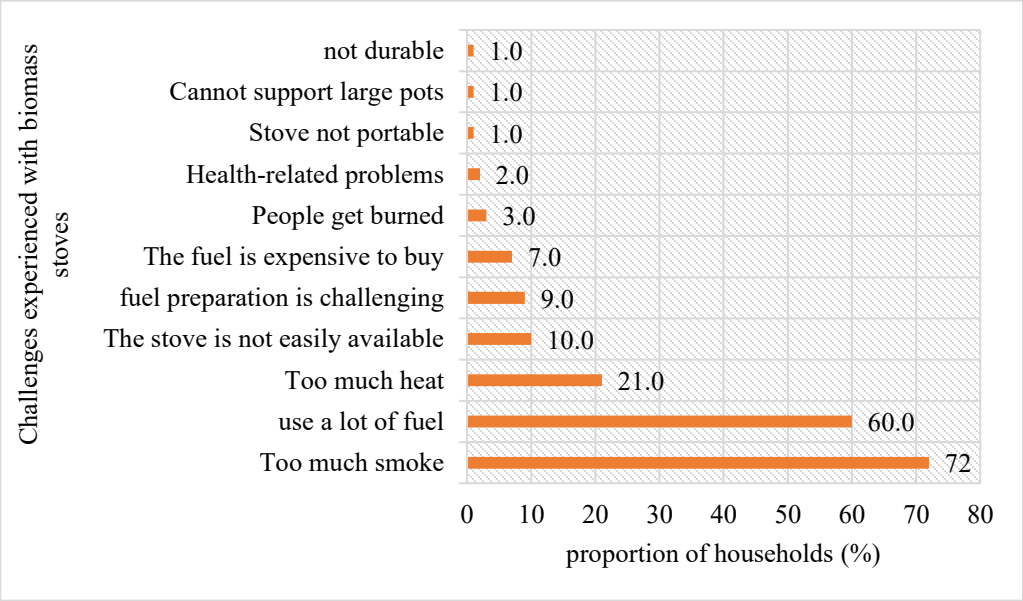

Figure 12: Challenges experienced with improved biomass stoves used by households

Factors and Preferences Shaping Improved Cookstove Use among Households in Lari Sub-County

A significant 54% of households identified fuel saving as a primary driver behind their utilization of improved cookstoves, highlighting a pronounced preference for cost-effectiveness and efficiency in household cooking practices (Figure 13). This finding aligns with findings from Thacker, Barger and Mattson (2014), whose systematic global review revealed that the potential for fuel savings is a compelling motivator for consumers to transition to clean cooking solutions. Many women expressed a preference for long-term use of ICS due to their ability to reduce fuel-gathering efforts. Approximately (43%) of participants highlighted faster cooking times as a key factor in their utilization of improved cookstoves, reflecting preference for time-saving solutions in food preparation, a finding that aligns with previous studies (Abdelnour, Pemberton-Pigott and Deichmann, 2020; Thacker, Barger and Mattson, 2014). However, this preference for speed contrasts with findings from a case study in peri-urban Kenya and Zambia (Jürisoo, Lambe and Osborne, 2018) where some users found rapid cooking speed inconvenient, citing difficulties in managing unattended compared to traditional stoves. This suggests a nuanced understanding of user needs where preferences for speed may not translate into satisfaction if they alter existing cooking practices and perceived efficiency.

The positive experiences of neighbors reported by 33% of respondents underscores the influential role of social networks and word of mouth in shaping adoption and use behavior. These social connections facilitate knowledge sharing and support community acceptance, motivating individuals to transition from traditional to cleaner cooking methods (Jagadish and Dwivedi, 2019; Kumar and Igdalsky, 2019). Additionally, stove

quality emerged as a crucial factor influencing consistent use, echoing prior studies that emphasize the importance of durability and reliability of the stove to a user (Crewe, 2020; Njenga *et al.*, 2017; Thacker, Barger and Mattson, 2015). Affordability is critical; if the price of an ICS is unmanageable, potential users are deterred from purchasing, hindering widespread adoption of CCTs. Additionally, the aesthetic appeal of stoves influences purchase decisions for some households; for example, Brooks *et al.*(2016) found that the modern appearance of the jikokoa stove motivated 40% of households to adopt it.

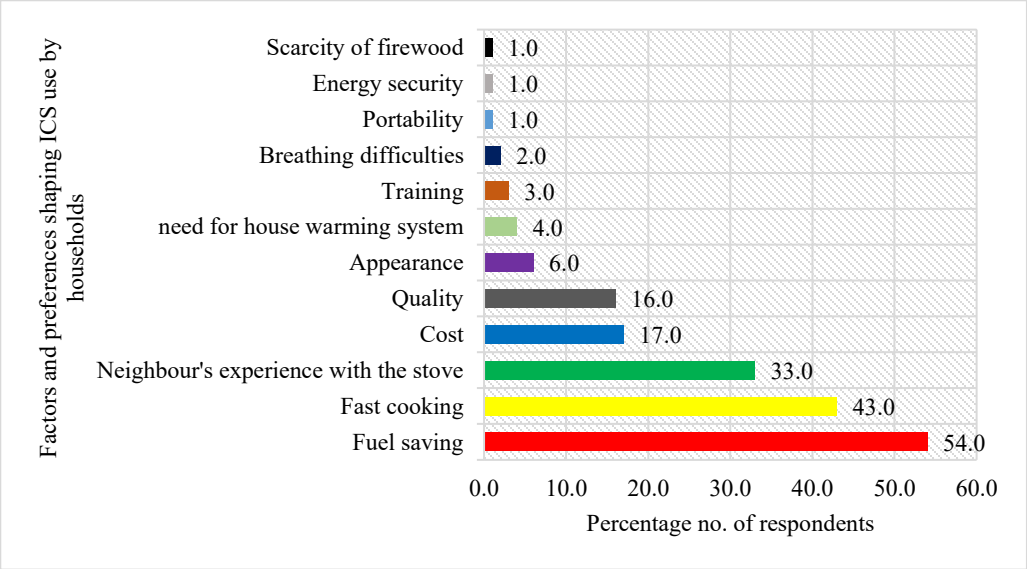

Figure 13: Factors influencing utilization of current ICS by households (n=100)

Fuel and Stove Sacking in Rural Households in Lari Sub-County

Stacking is a prevalent household practice, with approximately 97% households using multiple stoves and fuels, averaging three stoves and three fuels per household (Table 1). The most common fuel stacking combination involved firewood with charcoal and LPG, used by 30% of households (Figure 14), while the predominant stove stacking involved TSOF alongside KCJ and LPG, used by 23% of households (Figure 15). Similarly, all FGD participants reported stacking of at least three cooking fuels, with firewood being the predominant fuel in the stack. Ownership of clean cooking technologies did not translate to a complete transition because households used a mix of technologies, mainly to reduce cost and meet diverse cooking needs. Households stacked dirty and clean fuels due to high cost, limited availability, and accessibility of cleaner fuels. Stacking ensured cost savings and energy security when cleaner fuels were unavailable or unaffordable. These results align with Wang (2018), who discovered that household stacking is influenced by affordability, price, and availability of cooking fuels and the investment cost of new cooking solutions. Previous studies also indicate that the use of multiple stoves and fuels is common in Kenya, with approximately 51% households owning more than one cooking solution (Ministry of Energy, 2019).

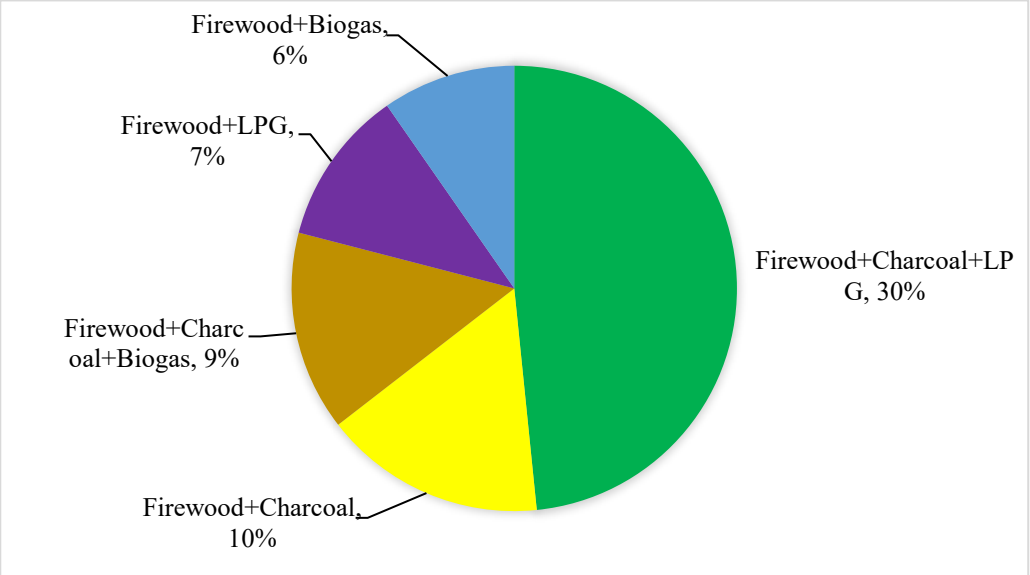

Figure 14: Most common fuel stack combinations among the rural households

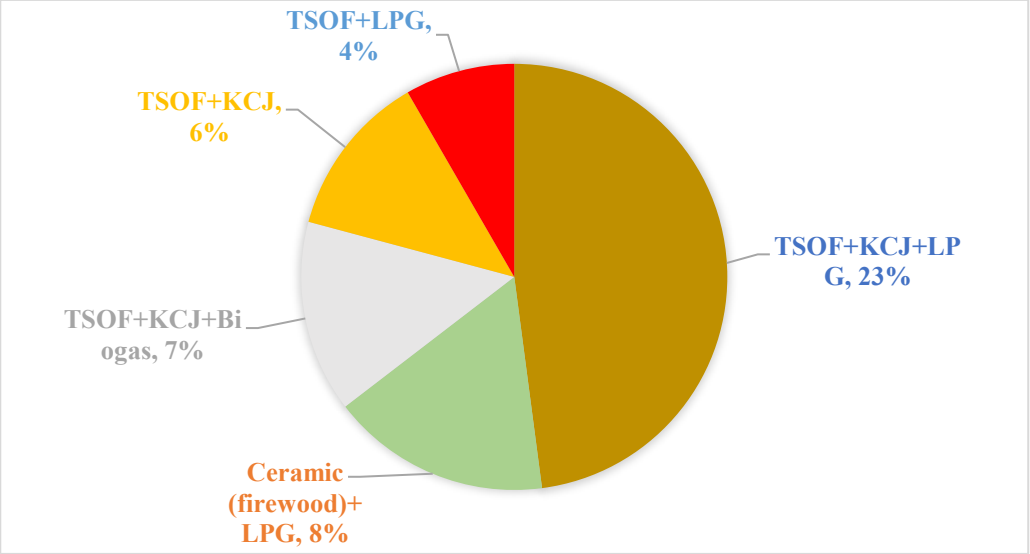

Figure 15: Common stove stack combinations among the rural households

Summarized Discussion of Findings

The results underscore the complex socio-economic and gendered factors influencing clean cooking technology utilization in rural households in Lari, Kiambu County. The persistent reliance on traditional fuels and stove stacking practices reflects economic constraints, cultural preferences, and perceptions of efficiency. For instance, despite high awareness of health risks associated with traditional cooking methods, households continue to use firewood and charcoal alongside cleaner options. This aligns with findings by Puzzolo *et al*. (2016) and Vigolo *et al.* (2018), who identified affordability, cultural acceptability, and availability as primary barriers to sustained use of clean

cookstoves. Similarly, Wang (2018) emphasized that when biomass fuels are readily accessible and inexpensive, households lack motivation to shift to cleaner alternatives, which this study confirms through the widespread use of firewood and charcoal sourced from farms and forests.

The gendered dimension is particularly pronounced; women are primarily responsible for fuel collection and household cooking tasks, exposing them to health risks such as respiratory illnesses and physical injuries, an observation supported by Njenga *et al*. (2021) and James *et al.* (2020). This burden remains largely unrecognized despite evidence from Gill-Wiehl, Price and Kammen, 2021 (2021) and WHO (2022) that women and children bear disproportionate health impacts from household air pollution. Membership in social organizations positively influenced stove adoption, echoing findings by Kumar and Igdalsky (2019) who highlighted the role of social networks in accelerating clean energy diffusion.

Furthermore, socio-economic factors such as household income sources and age significantly influence fuel choices. Households engaged in crop and livestock farming are more inclined to adopt clean cooking technologies like biogas and LPG, consistent with studies by Atieno and Odongo (2017) and Jan *et al*. (2017), which show higher adoption rates among wealthier or resource-rich households. Conversely, the low influence of education on stove ownership, despite a high literacy rate (94%), aligns with Troncoso *et al.* (2007), who found that formal education alone does not guarantee technology adoption; user preferences and cultural factors often override educational influence.

Cultural practices, particularly food taste from traditional cooking methods, continue to shape household stove preferences. The preference for traditional three-stone fires (TSOF), for certain staple foods like *ugali*, is consistent with Kong'ani, Ang'u and Muthama (2019), who documented cultural attachment as a barrier to clean cookstove adoption. The stove stacking phenomenon further complicates transition efforts, as highlighted by Wang (2018) and other energy studies in Kenya (Ministry of Energy, 2019), indicating that economic flexibility and fuel availability drive such practices.

Overall, these findings reinforce that the transition to clean cooking must go beyond technological solutions, incorporating socio-cultural and gender-responsive approaches. Addressing economic barriers through subsidies or microfinancing, and engaging women through capacity-building and decision-making roles, as recommended by Njenga *et al*. (2017) and Katutsi *et al.* (2023), is critical. The significant role of agroforestry practice suggests sustainable land-use practices can support cleaner fuel sources, while the involvement of social groups underscores the importance of community-based strategies in scaling adoption and sustained use.

Conclusion and Policy Implications

This research emphasizes the critical need to address underlying socio-cultural and economic factors that influence energy choices in rural communities. It reveals that technological solutions alone are insufficient; meaningful progress depends on fostering community-driven approaches that recognize local realities and gender dynamics. The

findings reveal that socio-economic factors such as age of household head, primary income source and social group membership significantly influence fuel choice, though they do not significantly affect clean cooking technology ownership in this specific context. Nevertheless, the daily realities of household energy decisions and practices, particularly the gendered division of labour in fuel collection, demonstrate that ingrained gender roles remain influential despite the statistical insignificance in outright ownership. Additionally, prevalence of firewood collection from on-farm trees emphasizes the importance of integrating clean cooking solutions with local agroforestry practices. This offers a sustainable pathway to promote clean energy, improve health and reduce drudgery associated with fuel collection. Furthermore, Focus Group Discussions revealed that government initiatives for promoting clean cooking are largely absent, with only NGOs involved in awareness and distribution efforts. This highlights a governance gap that needs to be addressed to strengthen institutional support for clean energy transitions. The study recommends targeted gender-responsive interventions, increased government engagement and community-based strategies, including empowering women and supporting community champions, to facilitate widespread utilization of clean cooking technologies.

Policy makers and stakeholders in the clean cooking sector should adopt a comprehensive, gender-responsive approach that actively promotes gender equity throughout the design, implementation, and scaling of clean cooking technologies. Our findings suggest that policies should specifically target the unique needs of women by addressing socio-economic barriers such as income constraints and limited access to resources, while ensuring meaningful involvement of women in decision-making processes. For example, subsidies should be targeted to female-headed households and fuel-stacking households. Additionally, financing schemes can be more effective when integrated through social groups, leveraging social membership, which was found to be a significant determinant of adoption. Capacity-building initiatives are essential to empower women to assume leadership roles in promoting cleaner cooking solutions within their communities. Moreover, investing in agroforestry extension programs can help increase on-farm woody biomass supply, addressing fuel availability challenges. For successful implementation, key institutional actors such as County energy offices, NGOs, and community organizations should collaborate to ensure policies are practical, inclusive, and sustainable.

To ensure sustainability and equitable utilization, frameworks must make purchase and maintenance costs affordable through innovative mechanisms such as public-private partnerships, subsidies, and microfinancing tailored for women in low-income households. Ensuring continuous support for spare parts and technical training is vital to discourage fuel stacking. Collaborations with local organizations and launching awareness campaigns emphasizing health and environmental benefits can help overcome economic and cultural barriers, fostering widespread utilization and acceptance. Collectively, these strategies can advance health, environmental sustainability, and gender equity goals, laying the foundation for a more inclusive clean cooking transition. Future research should explore innovative pathways to bridge affordability gaps and enhance access for low-income households. It should also deepen understanding of social influences on technology uptake and develop strategies that integrate health, environmental, and gender considerations. By doing so, stakeholders can more

effectively catalyze equitable, resilient clean energy transitions that truly meet the needs of marginalized populations.

Acknowledgments

This study was conducted as part of the *Vil2Bio* project, titled *"Combining Village-Scale Biogas Production with Pyrolysis in Biomass Stoves for Off-Grid Sustainable Clean Cooking and Cold Production".* The project was generously supported by a research grant from the Long-Term Joint European Union Horizon and African Union Research and Innovation Partnership on Renewable Energy (LEAP-RE). The authors gratefully acknowledge all respondents who participated in the interviews during the field data collection. The authors would also like to express profound gratitude for the contributions and constructive feedback provided by the consortium members throughout the research process.

References

Abdelnour, S., Pemberton-Pigott, C. and Deichmann, D. (2020). Clean cooking interventions: Towards user-centred contexts of use design. *Energy Research and Social Science*, 70: 101758. DOI: https://doi.org/10.1016/j.erss.2020.101758.

Ahmed, A.A. (2024). Exploring Drivers of Household Energy Choice for Cooking : Evidence from Kenya. DOI: https://doi.org/10.1016/j.ecolecon.2022.107467.

Ajijur, S., Jette, R., Jacobson, B. and Robert, J. (2017). Finding alternatives to swidden agriculture : does agroforestry improve livelihood options and reduce pressure on existing forest ? *Agroforestry Systems*, 91(1): 185–199. DOI: https://doi.org/10.1007/s10457-016-9912-4.

Akintan, O., Jewitt, S. and Clifford, M. (2018). Culture, tradition, and taboo: Understanding the social shaping of fuel choices and cooking practices in Nigeria. *Energy Research & Social Science*, 40: 14–22. DOI: https://doi.org/10.1016/j.erss.2017.11.019.

Akomolafe, J.K. and Ogunleye, E.O.E. (2017). Determinants of cooking fuel choices in urban Nigeria. *Journal of Environmental Management and Tourism*, 8(1): 168–182. DOI: https://doi.org/10.14505/jemt.v8.1(17).17.

Alegre-Bravo, A. and Anderson, L. (2021). Understanding the Multidimensionality of Energy Access in Remote Areas of Developing Countries Using a Multivariable Statistics Approach. *Energy Proceedings*, 20. DOI: https://doi.org/10.46855/energy-proceedings-9318.

Batchelor, A.S. and Brown, E. (2020). Cooking Health Energy Environment and Gender (CHEEG)-Guiding Covid Recovery Plans. *Gamos. Loughb. Univ*, pp. 1–98. Available online at: https://mecs.org.uk/wp-content/uploads/2020/07/CHEEG-Covid-recovery-strategies-Final.pdf [accessed on 11 October 2025].

Bonan, J., Pareglio, S. and Tavoni, M. (2017). Access to modern energy: a review of barriers, drivers and impacts. *Environment and Development Economics*, 22(5): 491–516. DOI: https://doi.org/10.1017/S1355770X17000201.

Brief, P. (2025). A UNDP Approach and Policy Guide: No time to waste : Pathways to deliver clean cooking for all. UNDP. Available online at: Ahttps://www.undp.org/sites/g/files/zskgke326/files/2025-02/undp-no-time-to-waste-pathways-to-deliver-clean-cooking-for-all-v2.pdf [accessed on 11 October 2025].

Brooks, N., Bhojvaid, V. and Jeuland, M. (2016). How much do alternative cookstoves reduce biomass fuel use? Evidence from North India. *Resource and Energy Economics*, 43: 153–171. DOI: https://doi.org/10.1016/j.reseneeco.2015.12.001.

Clean Cooking Association of Kenya (2018). Assessment of the Supply and Demand of Cooking Solutions. . 176. Available online at: https://www.energy.go.ke/sites/default/files/KAWI/Publication/Kenya%20National%20Cooking%20Transition%20Strategy_Signed.pdf [accessed on 11 October 2025].

Crewe, E. (2020). The silent traditions of developing cooks. In: Grillo, R.D. and Stirrat, R.L. (eds.), *Discourses of Development*: London: Routledge, pp. 59–80. DOI: https://doi.org/10.4324/9781003136071-3.

Dagnachew, A.G., Hof, A.F., Lucas, L.P., Detlef, P. and Vuuren Van.. (2020). Scenario analysis for promoting clean cooking in Sub-Saharan Africa: Costs and benefits. *Energy*, 192: 116641. DOI: https://doi.org/10.1016/j.energy.2019.116641.

Diaz Ruiz, C. and Makkar, M. (2021). Market bifurcations in board sports: How consumers shape markets through boundary work. *Journal of Business Research*, 122(August 2020): 38–50. DOI: https://doi.org/10.1016/j.jbusres.2020.08.039.

Foncha, J.N. and Eforkwe, T.H. (2024). Empowering Rural Women through Agroforestry Practices: The Case of The Mount Oku Forest Region, Cameroon. *East African Journal of Forestry and Agroforestry*, 7(1): 227–239. DOI: https://doi.org/10.37284/eajfa.7.1.1971.

Gill-Wiehl, A., Price, T. and Kammen, D.M. (2021). What's in a stove? A review of the user preferences in improved stove designs. *Energy Research and Social Science*, 81: 102281. DOI: https://doi.org/10.1016/j.erss.2021.102281.

Gitau, J.K., Mutune, J. and Sundberg, C. (2019). Implications on Livelihoods and the Environment of Uptake of Gasifier Cook Stoves among Kenya ' s Rural Households. *Appl. Sci.* 9(6): 1205. DOI: https://doi.org/10.3390/app9061205.

Gitau, K.J., Mutune, J., Sundberg, C., Mendum, R. and Njenga, M. (2019). Energy for Sustainable Development Factors in fluencing the adoption of biochar-producing gasifier cookstoves by households in rural Kenya. *Energy for Sustainable Development*, 52: 63–71. DOI: https://doi.org/10.1016/j.esd.2019.07.006.

Iiyama, M., Neufeldt, H., Dobie, P., Njenga, M., Ndegwa, G. and Jamnadass, R. (2014).The potential of agroforestry in the provision of sustainable woodfuel in sub-Saharan Africa. *Current Opinion in Environmental Sustainability*, 6(1): 138–147. DOI: https://doi.org/10.1016/j.cosust.2013.12.003.

Israel, G.D. (1992). Determining sample size. University of Florida. Available online at: https://www.gjimt.ac.in/wp-content/uploads/2017/10/2_Glenn-D.-Israel_Determining-Sample-Size.pdf [accessed on 11 October 2025].

Jagadish, A. and Dwivedi, P. (2019). Deconstructing networks, unearthing consensus: Diffusion of 'cleaner' cookstoves in rural Himalayas of India. *Energy, Sustainability and Society*, 9(1): 1–13. DOI: https://doi.org/10.1186/s13705-019-0188-1.

James, B.S., Shetty, R., Kamath, A. and Shetty, A. (2020). Household cooking fuel use and its health effects among rural women in southern India-A cross-sectional study. *PLoS ONE*, 15(4): 1–12. DOI: https://doi.org/10.1371/journal.pone.0231757.

Jan, I., Ullah, S., Akram, W., Khan, N., Asim, S., Mahmood, Z., Ahmad, M. and Ahmad, S. (2017). Adoption of improved cookstoves in Pakistan: A logit analysis. *Biomass and Bioenergy*, 103: 55–62. DOI:

https://doi.org/10.1016/j.biombioe.2017.05.014.

Jürisoo, M., Lambe, F. and Osborne, M. (2018). Beyond buying: The application of service design methodology to understand adoption of clean cookstoves in Kenya and Zambia.*Energy Research and Social Science*, 39: 164–176. DOI: https://doi.org/10.1016/j.erss.2017.11.023.

Karanja, A. (2020). Adoption of improved biomass stoves in Kenya : a transect-based approach in Kiambu and Muranga counties Adoption of improved biomass stoves in Kenya : a transect-based approach in Kiambu and Muranga counties. *Environmental Research Letters*, 15(2). DOI: https://doi.org/10.1088/1748-9326/ab63e2.

Katutsi, V.P., Kaberuka, W., Ngoma, M., Yawe, B., Atukunda, R. and Turyareba, D. (2023). From smoke to sustainability: the role of socioeconomic factors in the continuous use of clean cooking technologies in Uganda. *Technological Sustainability*, 2(4): 404–422. DOI: https://doi.org/10.1108/TECHS-06-2023-0024.

Kiambu, C.G. (2022). County governement of Kaimbu County intergrated development plan 2022-2023. Available online at: https://dev.kiambu.go.ke/wp-content/uploads/2022/11/CADP-2022-2023-Draft-FINAL.pdf [accessed on 11 October 2025].

KNBS (2019). Distribution of Population by Administrative Units, 2019 Kenya Population and Housing Census. Kenya Bureau of Statistics, Nairobi. Available online at: https://www.knbs.or.ke/wp-content/uploads/2023/09/2019-Kenya-population-and-Housing-Census-Volume-2-Distribution-of-Population-by-Administrative-Units.pdf [accessed on 11 October 2025].

Kong'ani, L.N.S., Ang'u, C. and Muthama, N.J. (2019). Adoption of improved cookstoves in the peri-urban areas of Nairobi: Case of Magina area, Kiambu county, Kenya. *Journal of Sustainability, Environment and Peace*, 1(1): 19–24. DOI: https://doi.org/10.53537/jsep.2019.02.004.

Kooser, S.H. and Toman, M. (2018). Improved Biomass Cook Stoves for Climate Change Mitigation ? Evidence of Preferences, Willingness to Pay, and Carbon Savings. Available online at: https://openknowledge.worldbank.org/bitstream/handle/10986/29972/WPS8499.pdf [accessed on 11 October 2025].

Kumar, P. and Igdalsky, L. (2019). Energy Research & Social Science Sustained uptake of clean cooking practices in poor communities : Role of social networks. *Energy Research & Social Science*, 48: 189–193. DOI: https://doi.org/10.1016/j.erss.2018.10.008.

Ministry of Energy (2020). BioEnergy Strategy 2020-2027. 58. Available online at: https://repository.kippra.or.ke/handle/123456789/3017 [accessed on 11 October 2025].

Ministry of Energy (2022). Behaviour Change and Communication Strategy for Promoting Clean Cooking in Kenya. Government of Kenya, Nairobi. Available online at: https://repository.kippra.or.ke/bitstreams/87d171f0-3c29-4eea-8580-a8a45d5a3b8a/download [accessed on 11 October 2025].

Ministry of Energy (MoE) (2019). Kenya cooking sector study: Assessment of the supply and demand of cooking solutions at the household level: Abridged report. Nairobi: Ministry of Energy. Available online at: https://www.scribd.com/document/719974884/Kenya-MoE-Kenya-Cooking-

Sector-Study-2019 [accessed on 11 October 2025].

Mohapatra, S. and Simon, L. (2017). Intra-household bargaining over household technology adoption. *Review of Economics of the Household*, 15: 1263–1290. DOI: https://doi.org/10.1007/s11150-015-9318-5.

Mutune, J.M., Minang, P., Duguma, L. and Wainaina, P. (2024). East African Journal of Forestry & Agroforestry Can On-Farm Wood Meet the Global Wood Supply and Save Tropical Forests ? A Systematic Review. *East African Journal of Forestry and Agroforestry*, 7(1): 1–18. DOI: https://doi.org/10.37284/eajfa.7.1.1745.

Nayak, D., Sahoo, A.K. and Singh, V.P. (2018). Creating Livelihood Opportunities for Women through Agroforestry Systems. *International Journal of Tropical Agriculture*, 36(1). .

Njenga, M. (2017). Forest and tree planting : a most worthy investment. . Available online at: https://www.cifor-icraf.org/publications/pdf/articles/NA41699.pdf [accessed on 11 October 2025].

Njenga, M., Gitau, J.K. and Mendum, R. (2021). Energy Research & Social Science Women's work is never done : Lifting the gendered burden of firewood collection and household energy use in Kenya. *Energy Research & Social Science*, 77: 102071. DOI: https://doi.org/10.1016/j.erss.2021.102071.

Njenga, M., Liyama, M., Jamnadass, R., Helander, H., Larsson, L., Deleeuw, J., Neufeldt, H., Roing, K. and Sundberg, C. (2016). Gasifier as a cleaner cooking system in rural Kenya. *Journal of Cleaner Production*, 121: 208–217. DOI: https://doi.org/10.1016/j.jclepro.2016.01.039.

Njenga, M., Mahmoud, Y., Mendum, R., Liyama, M., Jamnadass, R., De Nowina, K.R. and Sundberg, C. (2017).Quality of charcoal produced using micro gasification and how the new cook stove works in rural Kenya. *Environmental Research Letters*, 12(9): 095001. DOI: https://doi.org/10.1088/1748-9326/aa7499.

Nyankone, B.O. (2018). Factors influencing adoption of improved cookstoves among households of Thuti location, Othaya, Nyeri County, Kenya (Doctoral dissertation). Available online at: https://erepository.uonbi.ac.ke [accessed on 11 October 2025].

Odongo, O.R. (2019). Factors influencing use and adoption of clean cooking technologies in rural households : A case study of Bondo Sub-County , Kenya (Doctoral dissertation, University of Nairobi). Available online at: https://erepository.uonbi.ac.ke [accessed on 11 October 2025].

Odongo, S.A. (2017). Factors Influencing Adoption Of Improved Cooking Stoves: The case studyof rural households in Busia County, Funyula Sub-county, Kenya. (Doctoral dissertation, University of Nairobi). Available online at: https://erepository.uonbi.ac.ke [accessed on 11 October 2025].

Puzzolo, E., Elisa, P., Stanistreet, D., Rehfuess, D., Bruce, E. and Nigel, G. (2016). Clean fuels for resource-poor settings: A systematic review of barriers and enablers to adoption and sustained use. *Environmental Research*, 146: 218–234. DOI: https://doi.org/10.1016/j.envres.2016.01.002.

Rehfuess, E. and Organization, W.H. (2006). *Fuel for life: household energy and health*. World Health Organization, Geneva. DOI: https://doi.org/10665/43421/9241563168.

Rehfuess, E.A., Puzzolo., Stanistreet, E., Pope, D., Bruce, D. and Nigel, G. (2014). Enablers and barriers to large-scale uptake of improved solid fuel stoves: a systematic review. *Environmental Health Perspectives*, 122(2): 120–130. DOI:

http://dx.doi.org/10.1289/ehp.1306639.

Reviews, B. and Index, H.D. (2020). United Nations Development Programme, Human Develop- ment Report 2020. The Next Frontier Human Development and the Anthropocene. New York: United Nations, pp. 231–235. Available online at: https://ssrn.4418010 [accessed on 11 October 2025].

Singh, A., Tuladhar, B., Bajracharya, K. and Pillarisetti, A. (2012). Assessment of effectiveness of improved cook stoves in reducing indoor air pollution and improving health in Nepal. *Energy for Sustainable Development*, 16(4): 406–414. DOI: https://doi.org/10.1016/j.esd.2012.09.004.

Thacker, K.S., Barger, K.M.C. and Mattson, C.A. (2015). Balancing technical and user objectives in the redesign of a peruvian cookstove. *Development Engineering*, 2: 12–19. DOI: https://doi.org/10.1016/j.deveng.2016.05.001.

Thacker, K.S., Barger, M. and Mattson, C.A. (2014). A global review of end user needs: Establishing the need for adaptable cookstoves. *Proceedings of the 4th IEEE Global Humanitarian Technology Conference, GHTC 2014*: 649–658. DOI: https://doi.org/10.1109/GHTC.2014.6970352.

Vigolo, V., Sallaku, R. and Testa, F. (2018). Drivers and Barriers to Clean Cooking : A Systematic Literature Review from a Consumer Behavior Perspective. *Sustainability*, 10(11): 4322. DOI: https://doi.org/10.3390/su10114322.

Wang, Z. (2018). Energy and Air Pollution. *Comprehensive Energy Systems*, 1–5: 909–949. DOI: https://doi.org/10.1016/B978-0-12-809597-3.00127-9.

WHO (2016). Burning Opportunity: Burning Opportunity: *Clean Household Energy*: 1–113. Available online at: https://www.afro.who.int/sites/default/files/2017-06/9789241565233_eng.pdf [accessed on 11 October 2025].

WHO (2018). Tracking SDG7: The Energy Progress Report 2018. World Health Organization, Geneva. Available online at: https://www.irena.org/publications/2018/May/Tracking-SDG7-The-Energy-Progress-Report/ [accessed on 11 October 2025].

WHO (2022). Compendium of WHO and other UN guidance on health and environment: 2022 update, WHO Fact Sheet. Available online at: https://www.who.int/en/news-room/fact-sheets/detail/arsenic [accessed on 11 October 2025].

World Bank (2011). 632170WP0House00Box0361508B0PUBLIC0. The International Bank for Reconstruction and Development/ THE WORLD BANK.

Doi: https://doi.org/10.33002/nr2581.6853.080311 Open Access

Appendix-A

QUESTIONNAIRE

Introduction and Consent to Participate in the Research
Informed Consent (to be read aloud by the interviewer before conducting the survey):

Hello. My name is Lilian Gakuhi and I am here on behalf of the University of Nairobi. We are conducting a socio-economic and political analysis of Top-lit Updraft gasifier (TLUD) in Kenya. Participation in this survey is voluntary and you are free to decline to answer any or all questions. All the information you give will be treated as confidential and will be used for this study only. If you agree to participate in this interview, it will take approximately 50 minutes. Do I have your permission to begin?

Yes (1) No (0)

Administrative information:
Note: The replies are coded with numeric values (0, 1, 2, 3, 4,). Other replies are strings that shall be later coded into numeric values. Each code are particular to the questions posed. Write just the code for each response, except when it is a string.

1 SECTION 1: DEMOGRAPHIC DATA

Q1a: May I know your name please: …….
Q1b: What is your phone number: ……
Q2: Gender of respondent (from observation): Male (1) …….. Female (2) ……..
Q3: What is your age? 20 - 30 years (1); 30 - 45 years old (2); 45 years and over (3). = ……..
Q4: How long have you lived in this village? Less than 2 years (1); 2-5 years (2); 6-9 years (3); More than 10 years (4). = ……
Q5: What is your relation to this household?

- Head of HH (1)
- Wife or husband (2)
- Son (3)
- Daughter (4)
- Mother (5)
- Father (6)
- Brother (7)
- Sister (8)
- Grandson (9)
- Granddaughter (10)
- Employee male (11)
- Employee female (12)
- Other Relative (13)
- Other Non-Relative (14)
- Others (specify)

Q6: What is your highest level of Education?

- No formal education (1)
- Primary unfinished (2)
- Primary on-going (3)
- Secondary on-going (6)
- Secondary completed (7)
- Vocational training unfinished (8)

- Primary completed (4) Vocational training on-going (9)
- Secondary – unfinished (5)

Q7: List the major source of income to the household (only one is to be selected)

- Crop farming (1)
- Animal farming (2)
- Trading/business (3)
- Casual laborer (4)
- Formal employment (5)
- Remittances (6)
- Other (specify) (88)…….

Q8: What is your marital status?

- Single (1)
- Married (2)
- Divorced (3) =……
- Separated (4)
- Widow/widower (5)
- Other (specify) (88)…….

Q9: How many people eat from this household daily?
_____Males; _____Females__

Q10a: Are you a member of any social organization group within your locality?
Yes (1), No (0) =……

Q10b: If yes, which of the following groupings are you a member:

- Church group (1)
- Women group (2)
- Youth group (3)
- Savings and loan group (4)
- Community based organization (5)
- Others (specify) (88)…….

2 SECTION 2: COOKING ENERGY

Q11a: What are the sources of cooking fuel for your household in their order of importance?
(Rank by indicating 1, 2, 3, to xxxxxxxx)

- Firewood (1); Sawdust (7)
- Charcoal (2); Kerosene (8);
- Crop residue (3); Biogas (9);
- Animal dung (4); LPG (10);
- Carbonized briquette (5); Ethanol (11)
- Non-carbonized briquette (6) Solar (12);

Q11b: On a scale of 1 to 5, where 1 is most available and 5 is least available', please rank the availability of the specific fuels that you use in your household.
……
……

Q12a: If using firewood, where do you mainly source it? *If collect, answer (Q16-Q19); If buy, answer (Q20-Q22)*

- Collect from own farm (1)
- Collect from neighbors farms (2)
- Collect from government forest (3)
- Buy (4) =……
- Barter/exchange (5)
- Borrow from friends (6)
- Other (specify) (88)

Q12b: After how long do you use the firewood after sourcing from each source?

- Immediately (1)
- After one week (2) =……
- After I see its well dried (3)
- Other (specify) (88)

Q13: If collect from on farm, how do you get firewood from on-farm trees?

- Cut down the whole tree but leave the stump to coppice (1)
- Pruning some of the mature tree branches (2)
- Cutting the top and all the branches (3) =…….
- Uproot the whole tree (4)
- Remove some stems from the coppice of the stumps (5)
- Collect the dead wood (6)
- Others (specify) (88): ……

Q14: If you use charcoal for household cooking, how do you source it?

- Buy (1)
- Make on my own farm (2)
- Collect charcoal remains from places where charcoal has been made (3)
- Harvest and cool charcoal from firewood stoves after cooking (4)
- Borrow from friends (5)
- Other (specify) (88):

Q15a: Do you harvest and cool charcoal from your biomass stove after cooking?
Yes (1), No (0). =……

Q15b: If yes, how do you use the harvested charcoal?

Questions to households that collect firewood

Q16a: Who collects firewood in your household? (*Specify the number of people in each category involved in firewood collection and their age*)

- Wife (1)
- Husband (2)
- Sons (> 18yrs (3)
- Daughters (>18yrs) (4)
- Male children (<18yrs) (5)
- Female children (<18yrs) (6)
- Male grandchildren (7)
- Female grandchildren (8)
- Female relatives (9)
- Male relatives (10)
- Male employees (11)
- Female employees (12)
- No relation (female) (13)
- No relation (male) (14)
- Other (specify and indicate gender) (88)……

Q16b: How does each of the person who collect firewood mainly transport it?

- Carry on head (1)
- Carry on the back (2)
- Use a bicycle (3)
- Use a wheelbarrow (4) =……..
- Use a bull cart (5)
- Use a hand cart (6)
- Use a donkey cart (7)
- Other, specify (88) ……

Q17: How often does your household collect firewood (per week)?

- All the time (1)
- Sometimes twice (2) =……..
- One time (3)

Q18: How many hours does it take on average from when the household member collecting firewood leave home until when they return from firewood collection *from your primary source*?

……
……

Q19: What is the approximate distance from the household to the firewood collection area?

_____Km (*respondent to give the one-way estimate of the distance from household to firewood collection areas*)

2.1 Questions to households that buy or pay for cooking fuel

Q20a: Which fuel is bought by your household?

- Firewood (1) Kerosene (6)
- Charcoal (2) Biogas (7)
- Crop residue (3) LPG (8)
- Animal Dung (4) Solar (9)
- Briquette (5) Other, specify (88)……

Q20b: On average how much money (Kes) do you spend on fuel per week?

Q20c: What quantity of fuel do you purchase per day/week/month and cost?

Fuel	Quantity	Unit (Liters, headload etc.)	Unit cost (Kes)	Time (per day, week, month etc.)	Cost per week	Cost per month

Q21. Who pays for the fuel purchased?

- Male spouse (1) Female grandchildren (6)
- Female spouse (2) Male relative (7)
- Sons (>18yrs) (3) Female relative (8)
- Daughters (>18yrs) (4) No relation (9)
- Male grandchildren (>18yrs) (5) Other (specify) (88)

Q22: Where do you buy the fuel?

- Neighbors (1)
- Traders within the village (2)
- Shopping/ trading Centre (3)
- Local agents/distributors (4)
- Others (specify) (88)

Doi: https://doi.org/10.33002/nr2581.6853.080311 Open Access

Q23: Please state your opinion for each of the given statement using the following scales:

- 1=Strongly disagree 2=Disagree 3=Neutral 4=Agree 5=Strongly agree

	Statement	Scale	Comment
I	Do you believe that membership to different social organization can influence ICS utilization?		
Ii	By social organization, there will be information exchange that can affect ICS utilization?		
Iii	Neighbors have influence on others on ICS utilization?		

3. SECTION 3: STOVE(S) USED BY HOUSEHOLD

Q24: What type of biomass (*firewood, charcoal, sawdust, briquettes etc.*) cook stove do you currently use?

- Three stone open fire (1)
- Mud stove (fire wood) (2)
- Mud stove (charcoal) (3)
- Ceramic (firewood) (4)
- Ceramic (charcoal) (5)
- Metal stove (fire wood) (6)
- Metal stove (charcoal) (7)
- Improved branded (firewood) (8)
- Improved metal with ceramic/clay liner (firewood) (9)
- Improved branded (charcoal) (10)
- Other specify (88)…….

Q25: Where does the household use the biomass cook stoves?

- Inside the house (1)
- Outside in the open (2)
- Outside in a verandah (3)
- Others specify (88)……..

Q26: What are the three main characteristics you like about the stove in order of priority starting with the one you like most?

- Fuel is cheap/easy to get (1)
- Use less fuel (2)
- Produce less smoke (3)
- Does not make the pots black (4)
- Warm space (5)
- Cooks fast (6)
- Cook a lot of food (7)
- Cook any type of food (8)
- Easy to handle (9)
- Anyone in the family can use it (10)
- Other specify (88)

Q27: What are three main challenges/problems you are experiencing with the stoves you use in order of priority? Starting with the problem experienced most.

- Too much smoke (1)
- Too much heat (2)
- Use a lot of fuel (3)
- The fuel is expensive to buy (4)
- People get burned (5)
- Food is undercooked (6)
- Alters the taste of food (7)
- Fuel preparation is challenging (8)
- Difficult to light (9)
- The stove not easily available (10)
- Other specify (88)

Q28: How many times do you use the stove each day/week and to prepare which meals?

Type of cook stove	Frequency of use		Meals preferred for cooking using the stove
	Per day	Per week	Breakfast (1), Lunch (2), Dinner (3)
Three stone fire (1) *Mud stove (fire wood)(2)* *Mud stove (charcoal) (3)* *Ceramic (firewood) (4)* *Ceramic (charcoal) (5)* *Metal stove (fire wood (6)* *Metal stove (charcoal (7)* Improved branded (firewood) (8) Improved metal with ceramic/clay liner (firewood) (9) Improved branded (charcoal) (10) *Others (specify) (88)*			

Q29*:* If you have an improved firewood and charcoal stove (ICS), how did you acquire it?

- Made it myself (1)
- Buy (2)
- Given by NGO (3)
- Got from our Chama (merry go round) (4)
- Given county government (5)
- Given by a relative (6)
- Other (Specify) (88)……..

Q30: If you bought, how much did you pay for the improved firewood/charcoal stove? (In KES)

Q31: How would you rate the cost?

- Cheap (1)
- Fair (2)
- Expensive (3)

Q32: If you own an ICS, what influenced your adoption?

- Fuel saving (1)
- Fast cooking (2)
- Appearance (3)
- Portability (4
- Quality (5)
- Costs (6)
- Training (7)
- Neighbor's/friend's experience with the stove (8)

- Other (specify) (88)……

Q33: For how long have you been using the above mentioned ICS?
Q34: Have you ever replaced or repaired your ICS?
Yes (1), No (0) = ……..
Specify if repair (1) or replace (2), =…….

Q35: If repair, what kind of repair did you did you do on it?
- Repair of body cracks (1)
- Repair on door (2)
- Repair on pot rests (3)
- Other specify (88)…….

Q36: If it was replacement, did you replace it with the same model?
Yes (1), No (0) =
If No, why?
Q37: Does the design of the improved stove meet all your household's cooking needs?
Yes (1), No (0) =……..
Q38: If no, what is your preferred or ideal stove design?
Q39a: Does the size of ICS affect your cooking?
Yes (1), No (0) =…….
Q39b: If yes how does it influence your cooking?
Q40: How accessible are improved cook stoves in terms of availability and proximity to your community?
- Easily accessible (1)
- Not accessible (2)

Q41: Are repair services for the improved stove available when needed?
- Easily available (1)
- Available but not frequent (2)
- Not available (3)

Q42: Who decides on the type of cook stove to be used by the household?
- Male household head (1)
- Female household head (2)
- Daughter above 18years (3)
- Son above 18years (4)
- All the household members (5)
- Others (specify) (88)……..

Q43: If not owning an improved biomass stove, what hinders you from owning one?
- I cannot afford (1)
- Don't know where to buy one (2)
- Have never heard about it (3)
- I have never seen one cooking (4)
- Others (specify) (88)……..

Doi: https://doi.org/10.33002/nr2581.6853.080311 Open Access

Q44: Are you able to save cost spent on cooking fuel (firewood and charcoal) by using the improved firewood and charcoal stove?

Yes (1), No (0) =…….

Q45: If making a cost saving, approximately how much do you save per week or month through reduced expenditure on fuel because of using improved firewood and charcoal stove, fuel and fire management practices?

- Amount saved per week……KES
- Amount saved per month.....KES

Q46: If not using the improved (firewood/charcoal) stove that you have in your household, what makes you not use it?

- Functionality issues (1)
- Not meeting all my cooking needs (2)
- It consumes a lot of fuel (3)
- It smokes a lot (4)
- It's difficult to light (5)
- Pots are not stable on it (6)
- Pot not fitting in the pot rest space (7)
- Others, specify (88)……

Q47: If yes, which features would you like the stove to have to meet your cooking and heating needs effectively?

- Cost-effectiveness (1)
- Accessibility (2)
- Availability (3)
- Performance (4)
- Others (specify) (88)…….

Q48: Have you heard of or seen a top lit updraft (TLUD) gasifier cook stove?

Yes (1), No (0) =……..

Q49a: Would you be willing to purchase a Top lit Updraft gasifier stove?

Yes (1), No (0) =……

Q49b: If yes, why?

Q49c: How much would you be willing to pay for the gasifier?

Indicate amount…… (KES)

Q49d: If the response in Q49a was No, what makes you not to be willing to buy the gasifiers?

4. SECTION 4a: BIOGAS

Questions for Biogas users

Q50: If your households uses biogas as cooking energy, which type of biogas system do you have?

- Flexi biogas (1)
- Fixed dome (2)
- Balloon (3)
- Floating drum (4)
- Polyethylene Tube Digester (5)

- Other (specify) (88)…….

Q51: How did you acquire the biogas system?

- Household paid an expert to install the system (1)
- An NGO built it for use (2)
- Through a micro-finance/co-operative supported project (3)
- Bought the ready and complete system from supplier (4)
- Others specify (88)……

Q52a: If you paid for the biogas system, did you pay upfront or in installation?

- Upfront (1)
- In installation (2)

Q52b: How would you rate the cost?

- Very cheap (1)
- Cheap (2)
- Fair (3)
- Expensive (4)
- Very expensive (5)

Q53a: Which organic waste do you use for biogas production?

- Poultry waste (1)
- Dairy cows waste (2)
- Pig waste (3)
- Agro waste from the farm (4)
- Kitchen waste (5)
- Market waste (6)
- Other specify (88)……

Q53b: Please rank the organic waste materials which you use to produce biogas based on their availability, starting with the most available (1) to the least available (****).

- Most available (1)
- Least available (xxxxxxxxx)

Q54: If using more than one waste type, which ones do you prefer most and why?
……
……

Q55: What type of burner/cooker do you use with biogas?
……
……

Q56a: Does biogas meet all your household's cooking needs?
Yes (1), No (0) =…….

Q56b: If No, list the cooking needs that are not met by biogas
……
…

Q57: What are the potential benefits you experience on your farm by using biogas?

- Energy cost saving (1)
- Effective waste management (2)
- Bio-fertilizer production (digestate) hence cost saving (3)
- Increased yields and income (4)
- No smoke in the kitchen (5)

- Saving time that would have been spent on firewood collection (6)
- Reduced workload due to reduced need for firewood collection (7)
- Other specify (88)

Q58a: Have you received any training or support related towards biogas technology? Yes (1), No (0) =

Q58b: If yes, describe the kind of support you received

…….

Q59 a: Are you happy with the performance of your biogas system? Yes (1), No (0) =

Q59b: If no, what challenges have you encountered?

Q60a: Do you measure the gas and digestate produced from your biogas system? Yes (1), No (0) =

Q60b: If yes, what quantity of;

(i) Gas is produced? (*Indicate unit per which duration/time e.g. per day, week etc.*)……

(ii) Digestate is produced?

Q60c: What are the current uses of the gas produced?

- For household cooking (1)
- Sell gas to neighbors (2)
- Other specify (88)

Q60d: What are the current uses of the digestate produced?

- Apply on the farm (1)
- Sell digestate to farmers (2)
- Other specify (88)

SECTION 4b: PERCEPTIONS AND ADOPTION OF BIOGAS AS A COOKING TECHNOLOGY

(Questions for Biogas non-users)

Q61: Have you heard about biogas as a cooking energy source before? Yes (1), No (0) =……

Q62: How familiar are you with the concept of biogas?

- Not familiar (1)
- Somewhat familiar (2) =…….
- Very familiar (3)

Q63a: Are there any potential benefits which you think your household could realize through use of biogas for cooking? Yes (1), No (0). =……

Q63b: If yes, which are the benefits (list the benefits)……...

Q63c: Do you believe that using biogas is environmentally friendly? Yes (1), No (0). =……

Q63d: If yes; then tell me why/how?

Q64a: Are there any concerns or reservations you have about using biogas for cooking? Yes (1), No (0). =……

Q64b: If yes; what are these reservations? ……...

Q65a: Are there any barriers that might prevent you from adopting biogas as a cooking energy source?
Yes (1), No (0). =……
Q65b: If yes; list the barriers: ……
Q66a: How open are you to adopting biogas technology for cooking in your household?

- Not open (1)
- Somewhat open (2) =…….
- Very open (3)

: Q66b: If open, which system type would you prefer and why?

- Flexi biogas (1)
- Fixed dome (2)
- Balloon (3)
- Floating drum (4)
- Polyethylene Tube Digester (5)
- Other (specify) (88)……..

Q66c. How much are you willing to pay for the system that you prefer?
_____KES
Q67. Which type of waste do you produce in your farm which could be used for biogas production?

- Poultry waste (1)
- Dairy cows waste (2)
- Pig waste (3)
- Agro waste from the farm (4)
- Other (specify) (88)…….

Q68: If not willing to own a biogas, why would you not want to own one?

- 1don't have the necessary raw materials (1)
- I can't afford (2)
- Don't think it a good option (3)
- Have heard negative experiences with people who own then (4)
- Lack of space for installation (5)
- Other (specify) (88)

Q69: What factors do you believe would hinder the widespread adoption of biogas technology in the community?

- Cost (1)
- Infrastructure (2) =……...
- Awareness creation/Information/education (3)
- Misconception (4)
- Lack of suitable raw materials to feed the digester (5)
- Policy (6)
- Other specify (88)

Q70: To what extent do you think the community would be willing to support the implementation of biogas technology?

- Not willing (1)
- Somehow willing (2) =……
- Very willing (3)

Q71a: Are there any community-based initiatives or collaborations that you think could enhance the adoption of biogas on a larger scale? Yes (1), No (0). =…….
Q71b: If Q71a is yes; give us their name(s)?
……
Q72a: Are there any challenges related to infrastructure that you think need to be addressed to facilitate the scaling of biogas technology in the community? Yes (1), No (0). =……..
Q72b: if Q72a is yes; list them: …….
Q73a: Would you be willing to invest in setting up a biogas system for your household? Yes (1), No (0). =……
Q73b: If yes, tell us the reasons:
Q74a: Are you aware of any health-related benefits associated with using biogas for cooking?
Yes (1), No (0). =……..
Q74b: if Q74a is yes, list them: ……
Q75: Would you be open to participating in workshops or training sessions to learn more about biogas technology? Yes (1), No (0). =……
Q76: What additional features or support would encourage you and others in the community to embrace biogas technology...?

5. SECTION 5: BRIQUETTES

Q77: If your households uses briquettes for cooking, which type do you use?
- Carbonized briquettes (1)
- Non-carbonized briquettes (2)

Q78: How do you source the briquettes?
- Household members make them (1)
- Buy from neighbors who make them (2)
- Buy from market (3)
- Barter with other goods (4)
- Others (specify) (88)

Q79: Which raw materials do you mainly use to make the briquettes?
- Charcoal dust (1)
- Binding materials (2)
- Saw dust (3)
- Rice husk (4)
- Coffee husk (5)
- Sugarcane bagasse (6)
- Other (specify) (88)

Q80: What do you like about cooking with briquettes?
- They are affordable (1)
- Readily available (2)
- Smoke less (3)
- Burns for long (4)

- Safe to use in the house (5)
- Cooking utensils don't get dirty (6)
- Other specify (88)……

Q81: Which type of stove do you use with briquettes?

- Ordinary charcoal stove (1)
- Stove made specifically for briquettes (2)
- Permanent mud stove (3)
- Three stone open fire (4)
- Other specify (88)……..

Q82: How did you acquire the stove used with briquettes?

- We made for ourselves (1)
- Bought from the market (2)
- Given by an NGO (3)
- Other specify (88)

Q83: If making own briquettes, do you also produce for sale?
Yes (1), No (0) =
Q84: What do you use for making briquettes?

- Compact by hand (1)
- Compact in old plastic container (2)
- Make using manual presses (3)
- Other specify (88)

Q85a: Have you ever been trained on briquette making?
Yes (1), No (0) =
Q85b: If yes, by who?
…….

7. SECTION 7: HOUSEHOLD HEALTH AND ENVIRONMENTAL CONSERVATION

Q86a: Has any member of the household suffered from a respiratory disease in the past one year?
Yes (1), No (0)
=……
Q86b: If yes, which disease?
Q86c: Can the disease be associated with indoor air pollution?
Yes (1), No (0)
=……..
Q87: Which of the following environmental conservation activities do you participate in?

- Tree planting (1)
- Communal waste collection and disposal (2)
- Soil erosion control (3)
- Adopting of green farming practices (4)
- Waste recycling (5)
- Water conservation (6)

- None (7)
- Other specify (88)

8. SECTION 8: INSTITUTIONAL OR POLITICAL FACTORS

Please state your opinion for each of the given statement using the following scales: 1=strongly disagree, 2=disagree, 3=Neutral, 4=agree, 5=strongly agree

	Statement	Scale	Comments
Q88	The nearby government institution (through development agents of CBOs) can influence utilization of improved cook stoves		
Q89	By providing services (e.g. Awareness creation, quality control and monitoring) government institution can influence rural households ICS utilization.		
Q90	By providing supports (e.g. materials, technical, financial) institution can affect the utilization of ICS.		
Q91	Community groups e.g. *camas* can influence the uptake and utilization of ICS		
Q92	Decentralizing ICS production site to users can affect ICS purchasing decision by reducing its cost such as transportation cost		
Q93	By offering incentives to their customers (finance, subsidy) on the ICS institutions can increase uptake of ICS to the last miller.		
Q94	By offering post-acquisition support, institutions can influence the adoption of ICS		

Do you have any other recommendations/ remarks that you want to tell us?
……
……

Thank you for your attention and cooperation!!

Appendix B

FOCUS GROUP DISCUSSION GUIDE

Informed consent: (to be read aloud to the participants before the discussion)

Hello. My name is Lilian Gakuhi, and I am here on behalf of the University of Nairobi. We are conducting a study to analyze socio-economic factors related to use of cleaner cooking technologies in Lari. Participation in this discussion is entirely voluntary. You are free to decline to answer any questions or to withdraw at any time. All the information you provide will be kept confidential and used solely for the purpose of this research. If you agree to take part, the discussion will last approximately one hour. Do I have your permission to proceed?

1. What features or qualities would make a cooking technology more acceptable or appealing to your household?
2. How does the cost (initial or ongoing) of a clean cooking solution affect your willingness to adopt it?
3. Have you received any support or information from local organizations, or NGOs about cleaner cooking options?
4. In what ways can local institutions or leaders help promote and support the adoption of clean cooking technologies in your community?
5. What is the status of improved cookstoves technology adoption in the area?
6. What are some of the challenges faced by households in adopting ICS?
7. What are some of the constraints facing ICS actors (NGOs, Government actors, and other sectors in promoting ICS technology within this area?

Appendix C

KEY INFORMANT INTERVIEWS GUIDE

A. Sustainable Energy Strategies

1. What kind of after-sales technical support or maintenance services does SES provide to rural users and how accessible are these services in Kiambu County?
2. Are there trained local technicians or agents in rural areas who can assist with biogas installation and repairs? If not what is being done to build that capacity?
3. Installation cost has been reported as a major barrier. Does SES offer any financing plans, subsidies or partnerships to make systems more affordable for low-income households?
4. What efforts are made to educate users on alternative feedstock options?
5. Has SES considered user feedback in the design of its systems for rural households?
6. Does SES work with local governments, NGOs or CBOs in promoting and supporting biogas adoption? If so how?
7. How does SES monitor the usage and performance of its systems after installation, particularly in rural settings?
8. Are there any policies and regulations with regard to piping of biogas?
9. Does your organization offer any kind of incentive to your customers to encourage increased biogas uptake?
10. What are SES plans to scale up adoption in rural counties like Kiambu, and how do you plan to overcome barriers?

B. New Josman Juakali Agencies

1. Tell me about your experience in jiko fabrication- how long have you been doing this?
2. What types of jikos do you specialise in, and who are your typical clients?
3. What materials do you commonly use and where do you source them?
4. What design features make your improved jikos more efficient than traditional ones?
5. Do you modify jiko designs based on customer's feedback or specific needs?
6. What are the most common reasons customers give for wanting improved jikos?
7. What type or size of jikos are most in demand?
8. How do cost and affordability affect the uptake of improved jikos among institutions?
9. Do you offer any payment plans or work with NGOs or government programs to reach more clients?
10. What are the biggest challenges you face as a fabricator? (material cost, competition, regulation)
11. Have you faced any challenge with customer satisfaction or product performance?
12. Do you receive any support? (Technical training, access to finance, tools, from government or NGOs?
13. How familiar are you with clean cooking initiatives or policies in Kenya
14. What do you think needs to be done to improve adoption of cleaner cooking technologies?
15. What support do you think artisans like yourself need to scale up and improve clean cooking access in rural areas?

.

Authors' Declarations and Essential Ethical Compliances

Authors' Contributions (in accordance with ICMJE criteria for authorship)

Contribution	*Author 1*	*Author 2*	*Author 3*	*Author 4*	*Author 5*	*Author 6*
Conceived and designed the research or analysis	Yes	Yes	Yes	Yes	No	No
Collected the data	Yes	No	No	No	No	No
Contributed to data analysis & interpretation	Yes	Yes	No	No	No	No
Wrote the article/paper	Yes	No	No	No	No	No
Critical revision of the article/paper	Yes	Yes	Yes	Yes	Yes	Yes
Editing of the article/paper	No	Yes	Yes	Yes	Yes	Yes
Supervision	No	Yes	Yes	No	No	No
Project Administration	Yes	Yes	No	No	No	No
Funding Acquisition	No	Yes	No	No	No	No
Overall Contribution Proportion (%)	30	20	15	15	10	10

Funding
The project was generously supported by a research grant from the Long-Term Joint European Union Horizon and African Union Research and Innovation Partnership on Renewable Energy (LEAP-RE).

Research involving human bodies or organs or tissues (Helsinki Declaration)
The author(s) solemnly declare(s) that this research has not involved any human subject (body or organs) for experimentation. It was not clinical research. The contexts of human population/participation were only indirectly covered through literature review. Therefore, an Ethical Clearance (from a Committee or Authority) or ethical obligation of Helsinki Declaration does not apply in cases of this study or written work.

Research involving animals (ARRIVE Checklist)
The author(s) solemnly declare(s) that this research has not involved any animal subject (body or organs) for experimentation. The research was not based on laboratory experiment involving any kind animal. The contexts of animals were only indirectly covered through literature review. Therefore, an Ethical Clearance (from a Committee or Authority) or ethical obligation of ARRIVE does not apply in cases of this study or written work.

Research on Indigenous Peoples and/or Traditional Knowledge
The author(s) solemnly declare(s) that this research has not involved Indigenous Peoples as participants or respondents. The contexts of Indigenous Peoples or Indigenous Knowledge were only indirectly covered through literature review. Therefore, an Ethical Clearance (from a Committee or Authority) or prior informed consent (PIC) of the respondents or Self-Declaration in this regard does not apply in cases of this study or written work.

Research involving Plants
The author(s) solemnly declare(s) that this research has not involved the plants for experiment and field studies. Some contexts of plants are also indirectly covered through literature review. Thus, during this research the author(s) obeyed the principles of

the Convention on Biological Diversity and the Convention on the Trade in Endangered Species of Wild Fauna and Flora.

Research Involving Local Community Participants (Non-Indigenous) or Children
The author(s) solemnly declare(s) that this research has directly involved local community participants or respondents belonging to non-Indigenous peoples. However, this study has not involved any child in any form directly. The contexts of different humans, people, populations, men/women/children and ethnic people were only indirectly covered through literature review. Therefore, prior informed consent (PIC) of the respondents or Self-Declaration in this regard applies in case of this study.

PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses)
The author(s) has/have NOT complied with PRISMA standards to an extent.

Competing Interests/Conflict of Interest
Author(s) has/have no competing financial, professional, or personal interests from other parties or in publishing this manuscript. There is no conflict of interest with the publisher or the editorial team or the reviewers.

Attribution and Representation
All opinions and mistakes are the author(s)' own and cannot be attributed to the institutions they represent. The publisher is also not responsible either for such opinions and mistakes in the text or graphs or images.

Declaration of the Use of AI
During the preparation of this work, the authors used no AI to assists the script translation, language editing, grammar correction, reference management, improving readability and proof reading.

Rights and Permissions

Open Access. This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license, and indicate if changes were made. The images or other third-party material in this article are included in the article's Creative Commons license, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons license and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this license, visit http://creativecommons.org/licenses/by/4.0/.

***

To see original copy of these declarations signed by Corresponding/First Author (on behalf of other co-authors too), please download associated zip folder [Declarations] from the published Abstract page accessible through and linked with the DOI: https://doi.org/10.33002/nr2581.6853.080311.

INFORMATION AND CONSENT FORM FROM RESPONDENTS
(Non-Indigenous Respondents)
This form was translated into local language for the respondents

Title of the Research: Gendered Patterns Influenced by Socio-Economic Factors in Clean Cooking Technology Preferences in Rural Kenya in Lari, Kiambu County

Principal Researcher:	Lilian Nyambura Gakuhi Department of Earth and Climate Sciences, University of Nairobi, Nairobi, Kenya P.O Box 30197-00100, Nairobi, Kenya
Research Supervisor:	Jane Mutune Department of Earth and Climate Sciences, University of Nairobi, Nairobi, Kenya P.O Box 30197-00100, Nairobi, Kenya

A) INFORMATION TO PARTICIPANTS

1. Objectives of the research
The objectives of this study were to examine the socio-economic factors and preferences that shape clean cooking technology preferences in rural households in Lari, Kiambu County, with a focus on women's roles and gender equity.

2. Participation in research
Introduction and Consent to Participate in the Research :
The researcher will ask you several questions related to the topic. Participation in this survey is voluntary. All the information you give will recorded in written form and will be treated as confidential and used for this study only. If you agree to participate in this interview, it will take approximately 50 minutes. Do I have your permission to begin?

3. Risks and disadvantages
There is no particular risk involved in this project. You may, however, refuse to answer any question at any time or even terminate the interview.

4. Advantanges and benefits
You will receive intangible benefits even if you refuse to answer some questions or decide to terminate the interview. You will also contribute to a better understanding of the gendered clean cooking technology preferences and exposure patterns which will provide critical evidence for interventions aimed at reducing health risks associated with traditional cooking methods, particularly indoor air pollution.

5. Confidentiality
Personal information you give us will be kept confidential. No information identifying you in any way will be published. In addition, each participant in the research will be assigned a code and only the researcher will know your identity.

6. Right of withdrawal

Your participation in this project is entirely voluntary and you can at any time withdraw from the research on simple verbal notice and without having to justify your decision, without consequence to you. If you decide to opt out of the research, please contact the researcher at the telephone number or email listed below. At your request, all information concerning you can also be destroyed. However, after the outbreak of the publishing process, it is impossible to destroy the analyses and results on the data collected.

B) CONSENT

Declaration of the participant

- ⇨ I understand that I can take some time to think before agreeing or not to participate in the research.
- ⇨ I can ask the research team questions and ask for satisfactory answers.
- ⇨ I understand that by participating in this research project, I do not relinquish any of my rights, including my right to terminate the interview at any time.
- ⇨ I have read this information and consent form and agree to participate in the research project.
- ⇨ I agree that the interviews be recorded in written form by the researcher: Yes ( ) No ( )

Signature of the participant : _____ Date : _____

Surname : _____ First name : _____

Researcher engagement

I explained to the participant the conditions for participation in the research project. I answered to the best of my knowledge the questions asked and I made sure of the participant's understanding. I, along with the research team, agree to abide by what was agreed to in this information and consent form.

Signature of the researcher : Date : 22-04-2024

Surname: Gakuhi First name: Lilian

- ⇨ Should you have any questions regarding this study, or to withdraw from the research, please contact Mrs Lilian Nyambura Gakuhi by e-mail liliannyambura624@gmail.com
- ⇨ If you have any concerns about your rights or about the responsibilities of researchers concerning your participation in this project, you can contact the University of Nairobi, -30197, Nairobi, Kenya by email liliannyambura624@gmail.com